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Adama Science & Technology University

SCHOOL OF ELECTRICAL ENGINEERING & COMPUTING

DEPARTMENT OF COMPUTING

A MASTER'S THESIS

ON

Building Federated Cloud based E-learning Infrastructure Resource Allocation for Higher Education Institutions in Ethiopia

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS OF THE DEGREE OF

MASTER OF SCIENCE IN SOFTWARE ENGINEERING

BY:

BERHANU SISAY

January, 2017

Adama, Ethiopia

DECLARATION

I, declare that this thesis is my original work and has not been presented as a partial degree requirement for a degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

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Berhanu Sisay

This thesis has been submitted for examination with my approval as university advisor

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Dr. Dereje Yohannes (Asst. Professor)

January, 2017

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Berhanu Sisay

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Acknowledgement

Frist of all, I would like to thanks and Praise the almighty God & Blessed Virgin Mary for their incredible guidance, support and blessing my life in all my activities.

This thesis appears in its current form due to the support and guidance of several people.

Firstly, I would like to express my sincere gratitude and heartfelt thanks to my advisor Dr. Dereje Yohannes (Asst. professor) for his dedicated help, advice, inspiration, encouragement and continuous support throughout my thesis work. I would like to extend my appreciation to our department head Mr Mohammed Kemal for successful accomplishment of my thesis work.

Secondly, I am greatly obligated to forward my gratitude to my parents and my families for their intensification of the whole spectrum of my life.

Thirdly, I would like to thank everyone who has contributed positive impact to the successful realization of this thesis work.

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List of Abbreviations and Acronyms

AWS: Amazon Web Services

CPU: Central Processing Unit

CloudIA: Cloud Infrastructure and Application

CMS: Cloud Management System

CSP: Cloud Service Provider

CD: Compact Drive

CDN: Content Delivery Network

CRM: Customer Relationship Management

DC: Data Centre

HEI: Higher Educational Institutions

ICT: Information Communication Technology

IT: Information Technology

IaaS: Infrastructure as a Service

IEEE: International Electrical and Electronics Engineering

LMS: Learning Management Systems

LDAP: Lightweight Directory Access Protocol

NIST: National Institute of Standards and Technology

PaaS: Platform as a Service

QOS: Quality of Service

RAM: Random Access Memory

REST: Representational State Transfer

ROI: Return on Investment

SCP: Server Container Platform

SLA: Service Level Agreements

SOA: Service Oriented Architecture

SaaS: Software as a Service

SQL: Structured Query Language

TCP/IP: Transmission Control Protocol/Internet Protocol

VM: Virtual Machine

VPC: Virtual Private Cloud

Abstract

The objective of this study was to establish a cloud federation to interconnect several type data centre that are located at different geographical region together to provide an adequate e-learning resourceinfrastructure for Ethiopian public higher educational institutions. Cloud federation was used integrate different cloud resource of e-learning system and offer an excellent resource utilization for several universities. Federated cloud based e-learning system was also used to provide a collaborative learning in the higher educational institutions. Currently, most of higher educational institutions have lack of infrastructure,resources are underutilized and there is no well collaboration among them. To solve these problems, we hadproposed cloud federation based resource allocation in order to provide a sufficient learning resource and infrastructures as well as to allow collaboration across several higher educations.

The methodologies to solve the challenge with an existing system wasquestionnaires, literature review, interviews and observation. For the implementation purpose, we had used cloudsim to simulate the proposed system. In this study, the framework and prototype for resource allocation in federated cloud e-learning system for several universities was presented depending on centralized cloud federation in which we can create a centralized broker to allocate virtual machine. Finally, we had also investigated that cloud federation based e-learning system were better than non-federated system in terms execution time and response time.

Keyword: E-Learning, Cloud Computing, Virtual Machine Allocation, Cloud Federation, Inter Cloud

1 Chapter One: Introduction and Background

1.1 Introduction

In this modern era, numerous technologies was being introduced day to day making the human life easier. In particularly, web based technologies had a huge contribution in reducing the people's routine work. At the same time, many institutions and universities introduce some new courses to give knowledge about these technologies and make people technical to deal with them well. However, institutions was facing with lack of experienced teachers to teach those technical courses to their students. To override this problem, many institutions introduce online education service for those courses. Hence, E-Learning was one of the best and most important technologies which help them to create a good learning environment. Although, they still had many problems regarding to required facilities and infrastructure to implement the traditional e-learning method to a wide range of educational institutes throughout the country.Many countries including developing nations such as Ethiopia was implementing the e-learning software solutions to improve their educational standard. By using cloud computing technology which was a properly dominate the traditional e-learning method to overcome those problem. Cloud computing can be used by many sectors in order to extend the capability of existing IT systems. Cloud computing can be added to e-learning system to create a cloud e-learning which can make e-learning over the cloud in educational institutions. Although we can create cloud based e-learning, it had a challenge such as limited amount resource, the integration or combining of resource from different cloud providers. Currently, higher educational institution are dispersed and increasing in the number so, in order to manage, control and provide resources universally, we need a federated cloud which interconnects all the institution together.By implementing federated cloud e-learning, we can solve the challenge in the cloud e-learning. In this research the researcher uses federated cloud computing in order to solve the problem related to e-learning in the higher educational institutions such as allocation of e-learning resource for all universities according to their demands.

Nowadays, the concept of cloud federation is a hot research area and it is one of the future computing on the cloud which is going to integrate various resource of cloud in order to scale up its service and allows the resource to be utilized in efficient manner. That was why we choose this research topic because there was no any kind research done on area federated

cloud based of e-learning resource allocation in Ethiopia and it was a new concept of cloud computing technology.

In this thesis, we had going to discuss the idea behind traditional web based e-learning system, cloud based e-learning system, the future cloud computing which was building up of cloud federation in educational sector, allocation of resource infrastructure in particularly, virtual machine allocation in cloud federation and finally, the implementation of it in federated cloud environment.

1.2 Background of Study

Currently, the existence of internet was place to read web page that allows user to access resource they need from different locations. Providing service over the cloud computing was growing rapidly and move their focus on investing anything as service. For instance it provides education as service. In Ethiopia higher educational institution have a traditional web based e-learning as a service in some universities. Cloud computing had changed the way application was accessed and developed. Now, we have a new e-learning system with the help of cloud computing in order to form federated cloud based e-learning system.

In Ethiopian context there was local web based portals for e-learning that can be managed by single organization and usually an e-learning currently implemented in almost many universities in Ethiopia. However, only few were growing fast with the utilization of e-learning system, some others were started to deployed the system but not well used it yet and few were not deployed and use it so that, there was no more uniform e-learning service in the Ethiopian universities.

Currently, they are about thirty six public universities and some of them are starting to use e-learning service however, others are not implementing the e-learning system in their institution. The researcher identified that some of these higher educations were established recently and they do not have e-leaning system deployed yet.

Given the increasing importance of cloud computing in recent years, the application of this technology in the field of learning had been of interest to researchers. Cloud based e-learning allows user to dynamically scale as demands fluctuate[1]. There were an exploration for the issues and method of data migration across the clouds in the cloud integration [2].

1.3 Problem of the Statement

Higher education in Ethiopia plays an important role in the developments of country by producing educated people every year. We know that, we had several higher educational

institutions in Ethiopia however; there was no interconnection among these universities in the exchanging or sharing of their educational resources. Apart from some newly or recently established universities, most of higher educational institution in Ethiopia were deploying e-learning system. However, the current e-learningsystems in the higher education had some limitation suchas:-

- There were no integration among them in order to share their educational resource across multiple universities so; there were huge limitations to combine e-learning service of various educational institutions. So that, there was a need of enabling connectivity across several e-learning datacentre in order to allocate resource among various higher educational institutions.
- Allocation of resource across several datacentre found in different geographical regions.
- There was lack of e-learning infrastructure resources management and accessibility. Huge investment involved in managing the traditional e-learning infrastructure. There was no return on investment and they were expending a lot of resource infrastructure. There was lack of training on the technology on how to use, insufficiency of infrastructure to run the service and sometime server was down and the service failure was noticed.
- Unavailability of e-learning resource, service, more capacity need and high demand in the optimum utilization of resources.
- There was limited collaboration among several universities.
- There was scarcity of ICT resources and infrastructure, internet connectivity and bandwidth issue, difficulty in engaging learners online, unwillingness to change learning environment, ethically harmful internet contents.

In order to solve the above problem, it was relevant to develop a federated cloud computing model to interconnect the cloud based e-learning application and data among different kind of cloud service provider. Thus, allows several higher education institutions to be collaborated, interconnected, access infrastructural resources, gain more capacity and save the cost of their expenditure.

1.4 Purpose of the Study

The purpose of building up federated cloud e-learning was to allow various Ethiopian higher educational institutions to be connected together in order to access a resource such as an e-

learning service, different software and hardware infrastructure from a common centralized place according to their demand and enabling them to embrace the advantages of cloud computing in terms of more computing resources, and more efficiency on application execution at lower expense and lower administration overhead. A federated cloud based e-learning systems were very much helpful to reduce the cost in the current e-learning technology by its widespread cloud source.

In particularly, in this study we were going to allocate virtual machine to various hosts and again submit various virtual machine resources to the cloud user based on their requests. These allocations of virtual machine were associated with cloud federation which contain a variety datacentre that were located at different regions. Through cloud federation, we can bring different datacentre together to one common place so that, we can allocate virtual machine to these dispersed datacentre in order to provide unlimited amount educational resources to several higher educational institutions.

1.5 Objectives of the Study

1.5.1 General Objective

The main objective of this research was to build up federated cloud e-learning and allocation of virtual machine in cloud federation model to offer cost effective and efficient resource utilization of an e-learning system in Ethiopia higher education institutions.

1.5.2 Specific Objectives

The specific objectives of this study are:

- To interconnect several Ethiopian HEI through a cloud federation.
- To provide infrastructure resource allocation in the cloud federation.
- To understand the resource utilization in the federated cloud based e-learning and providing the resource allocation among Ethiopian public higher educational institutions.
- To show virtual machine resource allocation in the cloud federation infrastructure.
- To improve capacity, availability, scalability of an e-learning infrastructure and collaboration among higher educational institutions through cloud federation.
- To identify the approach, benefit and challenge that web based e-learning as well as cloud based e-learning had in education sector.
- To identify the benefit and challenges of federated cloud computing in the formation of federated cloud e-learning system.

- To assure how the federated cloud based e-learning system was benefited the university community in the sharing virtual machine resource.

1.6 Research Questions

The research answers the following questions:

- How to integrate different cloud e-learning data centre and teaching infrastructure resource that were found in several public universities?
- How to several university infrastructure resource are allocated and what kind of educational infrastructure resource or service was being allocated and shared among higher educational institutions?
- How do cloud provider allocate a number infrastructure resource to various cloud user based on their demand in the federated cloud?
- What are the benefits and challenges of implementing federated cloud based e-learning system?
- How federated cloud system is better than non-federated systems in terms response time?

1.7 Scope and Limitation of the Study

1.7.1 Scope of the Study

The scope of the research could be:-

- Limited to assessing the current status of federated cloud based integration e-learning services in Ethiopian public HEI.
- Identify the main challenges and benefits that play major role in traditional learning, web based and cloud based e-learning and federated cloud e-learning as well as the future deployment model of computing.
- Identifying the various cloud service providers and selection among cloud computing platform and cloud simulation tools.
- Indicating how the federated cloud based e-learning system was helpful for the utilization resources and allows the resource to be uniformly accessed across various Ethiopian public universities
- Modelling a federated cloud computing for allocating of resource to process from various data centres.

- Building up cloud federation framework and model a federated cloud for the three Ethiopian higher educational institutions.
- Implementing virtual machine allocation across several cloud data centre found in three universities namely,Addis Ababa, Adama Science and Technologyand Hawasa universities.

1.7.2 Limitation of the Study

Some limitations of the study during this research carried out were the following.

- There were a limitation of ICT pools and class delivery.
- Lack of motivation and awareness about e-learning approaches.
- During the data collection process we face difficult in meeting the right person at the right time.
- Some useful site that support our study was blocked.
- Load shedding of electricity and lack of training facilities problem.
- The study would be more productive if it was conducted widely by including several universities of Ethiopia. However, due to time and finance limitation, the study was limited to only three universities from different generation such as Addis Ababa University, Adama Science and Technology University and Hawasa University.

1.8 Significance of the Study

The significance of these researches studies are:

- Motivate higher education institutions to think through alternative methods towards adoption or deployment of new way of ICT infrastructures with better efficiency.
- It provide a cost-effectiveness and reduce a vendor lock in problem to support the cloud user.
- For cloud service provider, it would maximize their resource and revenues.
- Create an integrated research activities and other service delivery.
- Better collaboration and integration within and between geographically distributed higher educational communities and working together for the common good.
- Create a platform for collaborative scientific, technological, e-learning service with shared computing infrastructure.
- The study gives novel visions to the concerned government sector organizations towards better and modernized investment in ICT budgeting on HEIs.
- The proposed federated cloud based e-learning system can be used as a starting point for the physical realization of the cloud services.

- Furthermore the study could be used as a reference point for further research and studies for new ICT utilization strategies, pick out new concept in cloud computing and frameworks to be considered in different governmental and non-governmental organizations of Ethiopia and the rest of the world.

1.9 Organization of the Thesis

This thesis was organized into seven chapters. Chapter one introduces the background of the study, problem of the study areas, significance of the study, the research objectives, research questions and scope and limitations of the study. Chapter two covers the review of the related literature and includes a conceptual explanation on e-learning, cloud computing, cloud based e-learning and concept of inter cloud. Chapter three investigate the research methodology and design that was used to carry out this research, Chapter four discuss about the selection of cloud computing tools to implement federated cloud resource allocation and choosing a candidates cloud provider to provide service for educational institutions. Chapter five presents the model and framework of resource allocation in federated cloud based e-learning. Chapter six presents the study analysis, implementation and validation of the results. Finally, Chapter seven comprises conclusions and recommendations of the research findings.

2 Chapter Two: Literature Review and Related Works

In this chapter we were going to studies the benefit that information technology brought to the education sector as well as the challenge that was resulted from using the technology. We can deeply discuss about cloud computing, traditional learning, web based e-learning system and cloud based e-learning system as well as the concept of inter cloud computing and its classification. To get the research started, a literature analysis was also done in the area of e-learning system, cloud computing e-learning, federated cloud based e-learning systems to understand all the challenge or benefits and indicate the factors to consider prior to adoption.

2.1 Cloud Computing

2.1.1 Definition of Cloud Computing

There are many definitions for the term cloud computing and we can define cloud computing as follows

- "Cloud computing is the computing which provided an on-demand, scalable, multi-tenant, self-service compute resource"[3].
- Cloud computing is using the internet to access someone else's software running on someone else's hardware in someone else's datacentre[4].
- "Cloud computing refers to accessing computing resources that are typically owned and operated by a third-party provider on a consolidated basis in one, or usually more, data centre locations[4]".
- Cloud computing is a computing paradigm, where a large pool of systems are connected in private or public networks, to provide dynamically scalable infrastructure for application, data and file storage. With the advent of this technology, the cost of computation, application hosting, content storage and delivery is reduced significantly[5].
- Cloud computing is a practical approach to experience direct cost benefits and it has the potential to transform a data centre from a capital-intensive set up to a variable priced environment. The idea of cloud computing is based on a very fundamental principal of reusability of IT capabilities[5].
- Forrester defines cloud computing as: "A pool of abstracted, highly scalable, and managed compute infrastructure capable of hosting end-customer applications and billed by consumption."

Generally, these definitions have common points but each term has been pointing different abilities of cloud computing because of the different aspects of definers. The expressed

advantages and key features are changing according to usage perspectives of businesses sectors. Here is the most widely accepted and working definition cloud computing given by NIST[3] and in this research, we have used this definition.

- "Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three delivery models, and four deployment models."

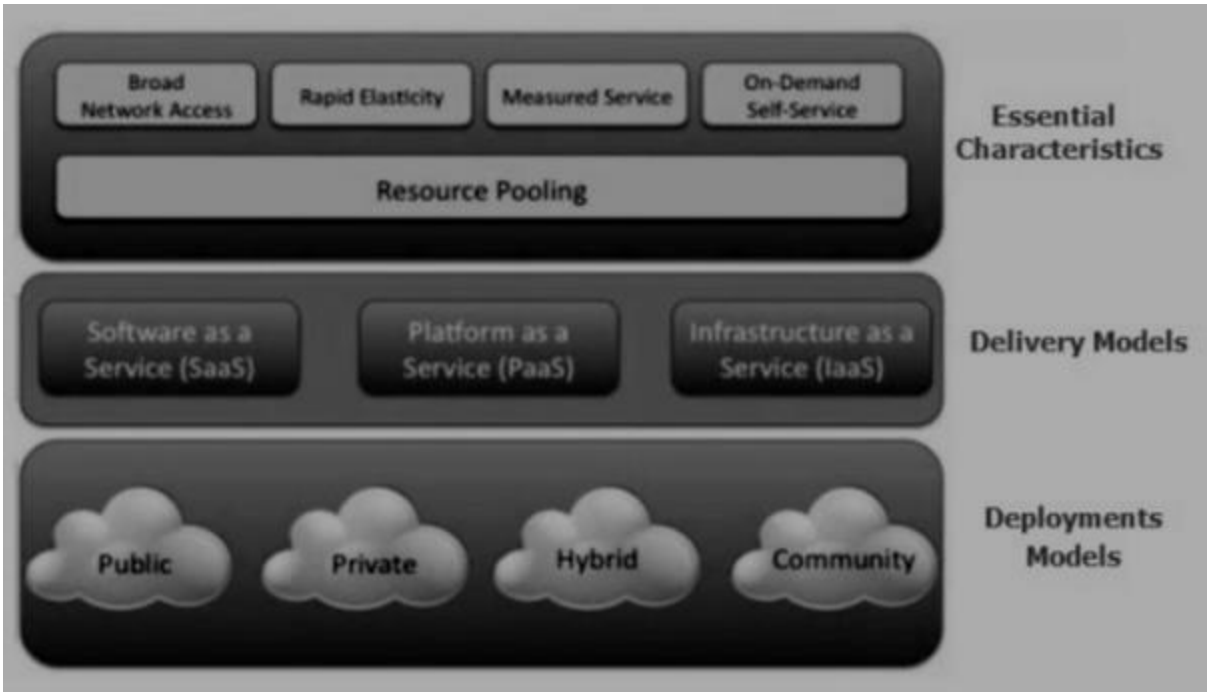

Figure 2-1: NIST Cloud Computing Definition[3]

2.1.2 Advantage of Cloud Computing

The following are the main advantage of cloud computing. These are

- It allows enterprises to get their application up and running very fast.
- It allows companies to avoid upfront infrastructure costs
- It improves the manageability and less maintenance cost.
- It adjusts resources to meet fluctuating and unpredictable business demand.
- It allows "pay as you go" model.

2.2 Cloud Computing Characteristics

2.2.1 Broad Network Access

This means it should be accessible over the internet across the entire network, not for a dedicated machine. In broad network access all capabilities are available over a network and can be accessible from anywhere by means of any client end devices for instance mobile phones, tablets, laptops, and workstations.

2.2.2 Rapid Elasticity

Elasticity is to mean where resource are available when you needed it[3]. It refers to optimal using of the resources in other words; we can stretch the resource as much as possible so that, if we optimal use our resource then, the resource is more available to us. In the rapid elasticity the computing capabilities can be elastically set-up and scaled rapidly according to the consumer demand.

2.2.3 Measured Service

It is pay as you go basis so that, we can easily know how much for the service we are using. In a measured service the resource usage can be monitored, controlled, and reported, providing transparency for both the provider and consumer.

2.2.4 On Demand Self- Service

It refers that whenever we need service, it is available to us. On-demand self-service offers the consumers computing capabilities such as network storage, server can be set up automatically whenever required without any need of human interactions.

2.2.5 Resource Pooling

It is multi-tenancy approach.In resource poolingthe cloud service provider pools their computers resources to multiple consumers with different physical resources dynamically assigned according to consumer demand for instance storage, processing, memory, and network bandwidth.

2.3 Cloud Computing Service Delivery Model

Cloud computing is able to provide a variety of services and the main three services are Infrastructure as a Service, Platform as a Service and Software as a Service.

2.3.1 Software as a Service

The software as service model for the e-learning system is that the e-learning software is hosted somewhere else in the cloud and then deliver applications to the browser of user or customer from the cloud. With SaaS the application is no longer installed in the local computer and it is on the cloud. SaaS provides the most used cloud applications to nearly everyone online.

In Software as a Service (SaaS), the software are offered to the end user as a service from the vendor based on their demands. "Usually, kind of standard application software functionality is offered within a cloud"[6].

For Software as a Service (SaaS), the installation, management and maintenance of software facilities are conducted by the cloud provider itself, who is either a third party service provider. Consequently, it is not necessary for the cloud provider to physically own the infrastructure that runs the software; they can either rent or lease it.

The main benefit from Software as a Service (SaaS) is its ease of accessibility. SaaS is usually available on demand and via the Internet and can thus be configured remotely. Thus, this service is highly cost-effective and location independent. In addition, organizations do not have to invest in costs related to maintenance or updates, since they are already covered by the provider[7]. Examples are Google's Gmail and Apps, instant messaging from AOL, Yahoo and Google.

2.3.2 Platform as a service

Platform as a service is the easiest way to get through a head to think about shared web hosting. By using platform as a service we found that, a folder somewhere in the cloud so that, we get the ability to use programming language such PHP, Perl, Ruby, Python etc., all that stored already on the server. We simple just run this application on the folder by simple hosting it on the platform and give us a service to actually a make functions.

Platform as a service (PaaS) delivers the whole set-up desired to develop and run applications over the internet. In Platform as a service (PaaS), the cloud provider manages and controls the cloud platforms for a particular type of application and the users cannot access the infrastructure lower than the platform. PaaS is based on a subscription model so user only pay for what they use[8].

The main benefit of Platform as a service (PaaS) in contrast with the other services is the vast platform alternatives it provides to the end users. End users can develop new applications using development tools, configuration management, and deployment platforms and

configurable remotely. However, the major challenges of Platform as a service (PaaS) are provider lock-in, flexibility in providing service to the user. In Platform as a Service model user can gain a rich set of APIs, web service technologies, scripting and programming languages from cloud service providers through a network.Examples include Microsoft's Azure and Sales force's.

2.3.3 Infrastructure as a service (IaaS)

In infrastructure as a service (IaaS), we move infrastructure or equipment on to the cloud. Infrastructure as a service(IaaS) is quite unique form of service obtainable in the domains of cloud-computing. The distinctive feature that differentiates this service from the other two is the control presented to the end-user. The ultimate principle of IaaS is based on the sympathetic, the IT resources are relevant to storage and database, or the hosting environment of VMs is managed and controlled by the cloud service provider. The end users utilize cloud services, but are incapable of accessing the infrastructures that host the services. IaaS offers virtual machines and other related hardware and software systems through a service Application Program Interface (API). Hence, an end user can use the resources on the basis of pay-per-use and the IaaS service provider controls the maintenance and is responsible for running the system[8]. IaaS saves the costs associated with IT infrastructure since it provides enhanced virtualization capabilities via service interfaces. Services pertinent to data and storage with potentially dynamic size, and data computing are subsequently provided through IaaS[6]. Some common examples of IaaS are Amazon SC2 and SC3, Google, Microsoft Azure and so on.

2.4 Cloud Computing Deployment Model

Basically, cloud computing can be deployed in different types namely, Public, Private, Hybrid and Community. Recently, researcher found that additional cloud computing deployment model such as Virtual Private Cloud and Inter Cloud. The following sub sections shall present the details.

2.4.1 Private Cloud

Private clouds are accessible only within a private network. The term private cloud is used to differentiate between standard and private computing. It is a marketing name for a proprietary computing in this cloud, hosting services are provided to particular number of people behind the fire-wall[8].

A private cloud operation is managed by same organization that utilizes its features, or a distinct vendor that functions on behalf of the organizations. The principal idea of private cloud is to ensure the security of the data and allow access only to the subscribers of the cloud facilitie[9]. Thus, private clouds are owned or leased by respective enterprises, whose functionalities are not directly exposed to the end users[6].

2.4.2 Public Cloud

Public clouds are clouds that are accessible and available publicly for any organization and individual users. Public clouds use the basic concept of cloud computing where user can use the resources on the basis of pay-per-use or pay-per-usage model [8]. Public cloud functions on the basis of the fundamental principle of cloud computing. Organizations throughout the globe use cloud services from other organizations, and concurrently may offer their own service to other organizations. This aspect consequently reduces the costs responsible for building and maintaining the IT infrastructure[6].

A cloud provider sells or rents the cloud services to multiple unrelated clients. The clients on the other hands do not worry about the maintenance and security of their data, since it is the vendors' responsibility to maintain and protect the data in public clouds[9].

2.4.3 Hybrid Cloud

This cloud is normally known as the combination of private and public cloud, where a vendor has its own private cloud and forms a connection with public cloud or vice versa. A hybrid cloud exhibits the characteristics of both public and private clouds. It achieves maximum cost reduction through outsourcing which is a feature of public clouds, and maintains high degree of control over sensitive data, which is a feature of private cloud[6].

2.4.4 Community Cloud

An interesting recent development is the development of a specialized form of public cloud known as a community cloud, sometimes known as a vertical cloud. These are public clouds organized around a group of competing/cooperating businesses in a particular vertical market, such as financial services.

Community cloud can be able to provide industry-specific capabilities (such as governance, auditing, and security) these can be thought of as a sort of shopping mall for cloud services, virtually (and perhaps physically) co-located to help all achieve a critical mass for customers interested in that vertical.

2.4.5 Virtual Private Cloud

A virtual private cloud is the subset of larger cloud infrastructure which consists of infrastructure as service computing, networking, firewall and storage offered by the service provider.

A virtual private cloud is the interconnection of cloud computing infrastructure resource with a virtual private network infrastructure in order to provide a notion of private set of cloud resources to their own infrastructure in a secure and transparent manner[1].

Virtual private network allows the cloud user to use any kind of IP address range in order to solve the conflict between them [8].

Virtual private cloud is also known as a "dedicated cloud" or "hosted cloud," this model results in a self-contained cloud environment hosted and managed by a public cloud provider, and made accessible to a cloud users[2].

A virtual private cloud is an implementation part of public cloud with virtual private network. The virtual private cloud is managed by cloud provider which allocates and provides the resource infrastructure for every cloud user of virtual private cloud and allows in isolating the data of cloud user VPC from public cloud users.

2.4.6 Inter Cloud

An inter cloud is a collection several clouds that are located in various geographical regions and interconnected together in order to provide sufficient resource to the end users. It consists of a small and large cloud. This kind cloud computing deployment is new and it is a future of cloud model. In a single service provider the resource might not fulfil the request coming from cloud user. However, in the inter cloud scenario,if the request for the resources comes from the cloud user is not fulfilled by cloud service provider then, it asks the resource from other cloud located somewhere in order to provide the requested resource to the cloud user. In this study we are proposing an intercloud deployment model[11]. Inter cloud can be classified into cloud federation and multi-cloud which we are going to discuss at the last section of this chapter.

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[1]After using this term, we have since found it also used on a blog post encouraging the use of VPNs and cloud computing.
http://www.elasticvapor.com/2008/05/virtual-private-cloud-vpc.html.

[2]http://whatiscloud.com/cloud_deployment_models/index

2.5 Cloud Computing Component

2.5.1 Data Centre

Data centres are physical or virtual infrastructure used by enterprises to house computer, server and networking systems and components for the company's IT needs such as storing, processing and serving large volumes of data to client in a client or server architecture.

The key requirements of data centre are:

- **Backup power supply**

Every organization that has a data centre have to ensure an interruptible or regular power supply so that, your work is not go down when they providing data to the end user.

- **Cooling systems**

As we know, when hundreds of thousands of servers working in a data centre, they would generate enormous amount of heat so, in order to dissipate this heat every single data centre should have a very strong cooling system.

- **Redundant network connections**

It prevents any kind of network interruption whether the data is in transit or requested by the client.

- **Policy – based security systems**

Every data centre should have physical as well as technical security of the systems that are stored on their premises. This should be maintained by very strict policy-based security systems.

- **Data centre management**

It ensures the reliability of the connection to the data centre and the consistency of the mission critical information stored within the data centre. Data centre are commonly run by large companies or government agencies. Data centre are used to provide cloud solution service for private and business applications.

2.5.2 Cloud Storage

In cloud storage, the digital data is stored in logical pools. These logical pools are physical storage spans multiple servers and location.

Cloud storage provider

They ensure that the irrespective of their data location is residing the availability of data should be there and the security and dependability of the physical environment is very critical.

Data stored can be for:

- End – user
- Organization
- Application

2.5.3 Virtualization Technology

In plain term virtual means something that is not real. In computing, when we have a single machine and this machine has tremendous amount computing power, storage capacity and random access memory. It may be require the same computer or hardware for running multiple operating system and allowing different operating system to store information application. This particular concept is known as virtualization. It is the most important and serves as a backbone or an engine to the cloud computing.

"Virtualization, in computing, is the creation of a virtual (rather than actual) version of something, such as a hardware platform, operating system, and storage device or network resources".

Using virtualization technology, we can save the resource of physical hardware machine. We know that, in the university to deploy e-learning system, we have to buy a physical server machine and the storage server. Assume that, if we need three server machines to deploy our application and three storage server to store our data and information then, it is possible to use these entire servers to run on the top a single physical machine through virtualization technology. This was done through the hypervisor which was used creates multiple instance of virtual machine.

It is possible to run multiple operating systems (virtual machine) on a single machine through hypervisor. In the hardware abstraction, what we basically have is sharing resource of physical infrastructure and we have multiple operating system which can directly access this resources via hypervisor. Virtualization is basically abstracts computer resources logically with the help of virtual machines. The cloud determines how those virtualized machines are allocated, delivered and presented. This virtual machine is combination CPU, storage, memory etc.

2.6 Information Technology in Higher Education Institutions

The education sector was historically shared a mutual relationship with information technology. While on one hand, the sector had been a supported for many technological innovations, on the other hand the technology had played a pivotal role in the evolution of education and academia. Information Technology played a catalytic role in making education a more collaborative and interactive process. In today's education system, students and educators are using technology in many areas such as face to face teaching and training, web based learning and examination, digital libraries, online experience sharing and so on.

"There are two great equalizers in life, the internet and education. By combining the two e-learning will be the great equalizer in the next century. By eliminating barriers of time, distance and socio-economic status, individuals can now take characteristics of their own lifelong learning."

John chambers (CEO of CISCO Systems)

Information technology had been used by educational institutions to simplify different business and educational processes. Apart from the obvious use of technology in the organized segment of the education sector, technology had also penetrated into the unorganized segment. Training programs, private tuitions and vocational training programs were some of the services that were being provided through the use of technology in the unorganized segment.

When we come to web-based e-learning mode, the system construction and maintenance were located interior of educational institutions or enterprises, which results in a lot of problems, such as a lot of investments were needed, but without capital gains to return, without development potential and staying power[12] . By applying cloud computing the entire problem with traditional web based e-learning was solved and education was enhanced further.

Table 2-1: Comparisons between web based computing and cloud based computing[10]

Models	Web Based Computing	Cloud based Computing
Logical Model	• Buy Assets • Build technical architecture	• Buy service • Architecture included
Business Model	• Pay for assets • Administrative Overhead	• Pay for use • Reduced

		administrative function
Technological Model	• Single –tenant ,non-shared • Static	• Multi-tenant, Scalable, Elastic. • Dynamic
Delivery Model	• Costly, Lengthy deployments • Land and expand staffing	• Reduced deployments time • Fast Return on Investment(ROI)

There are several advantages has been brought by Cloud Computing and facilities such as physical hardware reduction, saving network infrastructure expenses, cost reduction, reduce infrastructure expenses for IT in the higher educational institutions.

Cloud federation is also one of the future paradigms of cloud computing which further enhances the functionality of using cloud for the organization. The concept of federated cloud based for educational institution is clearly new. It is about bringing all higher educational institution resource under one single huge federated cloud learning infrastructure so that, resources are uniformly accessed by various institutions.

Let us discuss about the traditional learning, web based e-learning, federated cloud and cloud based e-learning on their approach, benefit, challenges in the higher educational institutions.

2.7 Traditional Learning Approach

In traditional class room education the knowledge is the center and the teacher is the leader. The teachers know understanding level of their students and answer their question's quickly in the class room. Traditional class room creates a good relationship between teacher and student as well as among the students. It is similar to every single student in the class.

2.8 Benefit of Traditional Learning

Traditional learning is providing many benefits to the educational sector. The following are some of the benefit of traditional learning.

- There is direct contact with lecturer, students and advisor.
- It is more suitable for hands on training
- There are more accesses to the campus activities.

2.9 Challenge of Traditional Learning

As the traditional learning has an advantage, there is also disadvantage in using traditional learning. The following are some of the challenge of traditional learning.

- It is less flexible in the class scheduling.
- It is less cost effective and more time consuming.
- It is more travel to and from classes.

2.10 Web Based E-learning Approach

E-learning is way delivering of education through ICT in order to improve the quality of education and quality of its product. It can also be defined as electronic learning in which the learning content is available online and provides automatic feedback to the student's learning activities. A web based e-learning system is what higher educational institution is used today. In this system the infrastructure resources are located inside organizations, they should have to purchase all the necessary hardware and software tools and it is the property of the organizations. In a modern technology a web based e-learning makes difficulties for higher educational institution because they have to deserve high upfront costs for hardware and software and higher educational institutions uses an half of their server resources. Therefore, most of higher educational infrastructures are underutilized especially during semester break and summer less usage of resources[13].

2.11 Benefit of Web E-Learning Systems

E-learning is a new trend in education that tries to make the best use of information technology (IT). The Implementation of web based e-learning in education sector has so many benefits; the following are some of the benefits[14]:

- E-learning is more cost saving and cost effective than traditional learning. It saves money by lowering the cost of buying equipment, learning material and cost of travel.
- E-learning is minimizing the challenge related to class room teaching of audience.
- E-learning is more flexible in such way that, learner can learn at their own pace, learner can control what to learn, when, where, and how. Unlike traditional way of learning on which the topic are scheduled or dedicated for the entire day. The user of e-learning on the other hand, can adjust the amount of learning by classifying into a module so that, they can focus on the lesson they need to learn. In additions learner can revise the topic as many times, fast or slow, as they like, until they can understand it.

- E-learning can reduces stress and increases satisfactions.
- E-learning can provide immediate access to the information's.
- E-learning is available on demand which allows learners to finish their learning conveniently at off time or from home.
- E-learning is an interactive and allows learner pushing them rather than pulling them through learning.
- E-learning provides learners to take personal responsibility for their own learning.
- New modes of providing education such as virtual learning environment, tele-schools and online education programs have enabled providers of education to cut across geographical boundaries. This has the potential to help governments especially in smaller cities and rural areas.

2.12 Challenge of the Web Based E-Learning Systems

There are currently many challenges regarding to web based e-learning ecosystem. The following are the challenge of current web based e-learning system[14].

- Technophobia
- Less availability of required technologies or lack of technological infrastructures resources.
- There is limited access to a computers as well as the internet connectivity.
- It required computer proficiency especially for the beginners. Mostly the beginners confronting consumed more time at the beginning of the courses.
- Feeling isolated and missing of social contact in other word, feeling that they communicate mostly with a machine rather than human beings.
- There is no adequate opportunity to discuss and interact with lecturers.
- Lack of maintenance and technical support when software crashes.
- Lack of resource utilization and infrastructure. There is inconsistent resource usage in a single university which results in large expenditure on resources and the relative underutilization of resources.

2.13 Cloud Based E-Learning Approach

We are more benefited when we applied cloud computing in collaboration with e-learning system and this forms cloud based e-learning system which brings about its virtualization structures of the hardware, it decreases the construction and maintenance cost of the e-learning resources andimprovesperformanceof the systems. Using cloud based e-learning

could lower infrastructure cost, lower software cost, increased computing power, improved compatibility between operating system, easily accessible from a range of devices, portability of document and easier group collaboration. The cloud user can access an e-learning material through end device such as smart phone, computers, and tablet as long as connected to the internet. The cloud provider is responsible to offer the services requested by the cloud user based on their demand[16]. From limitation point of view it is very important to have an internet connection otherwise, it is impossible to access the cloud service and accessibility is difficult if the internet connection is low.

Cloud computing is an attractive environment for students, faculty members and researchers. As an emerging IT, cloud computing can provide universities and research centers with powerful and cost-effective computational infrastructure. Students can connect to campus educational services through their personal mobile devices from anywhere. Faculty members can have efficient and flexible access to their course material in their class rooms. Researchers can find articles, models and run their experiments on the cloud faster than ever [17].

2.14 Benefit of Cloud based E-Learning Systems

There are several benefits of cloud based e-learning system in the educational institutions. Cloud computing has been presents a significant opportunities for the education sector from different angels. The following are a list of some major benefit cloud based e-learning systems[16].

- **It lowers the cost:** - Cloud user does not need to expend much more money to acquire a large amount of memory, CPU and data storage because;it is already available on the cloud. What the institution had to done was to pay for the resource going to be used in a cheaper price. For instance pay for storage in order to store all their data in the cloud storage.
- **The cloud reduces management burden for institutes: -** Technical issues related to the hosting and maintenance of online portals would be the responsibility of the Cloud services provider. And also universities that encourage research and development activities need dedicated IT teams for maintaining data centers and server farms. With the cloud offering PaaS and IaaS, maintenance of IT infrastructure is taken up by the cloud service providers.

- **Opening up research opportunities: -** One of the basic features of cloud computing is "resource pooling", as it is allows cloud users to share common resources. This feature opens up new opportunities for researcher.

- **An ease of accessibility:-** Any kind of resource we are going to be used with an e-learning cloud service such as teaching material, module, practical exercise, lecture note and so on, could be easily accessible and uploaded when ever need it.
- **Enable collaboration:** - It allows various students to share and discuss on their ideas, ask questions and work on their project and exercise by setting up a group or the forum over the cloud.
- **Applications are updated automatically**: - Cloud based application that is used in the learning and teaching process is automatically updated and the latest software is also available to the end users.
- **No need to have additional external device**: - We do not worry about the device such as flash drive or CD in order to carry the data from one device to another or to store data with the device and also whether we lose the device or not because, we have all our data in the cloud [18].
- **Both teacher and student are benefited**: - Both teacher and student are benefited from the cloud based e-learning systems in such a way that the teacher provide learning course material, lecture note, assignment, project and communicate with their student and the student on the other hand can take course material, hand out, send the their exam, project and assignment to and from their teachers.[19]
- **Improved improbability**: - It is almost impossible for any interested person to determine where is located the machine that stores some wanted data (tests, exam questions, results) or to find out which physical component needed in order to get a digital asset [20].

2.15 Challenge of Cloud based E-Learning Systems

Regardless of various advantages that Cloud has to offer to the e-learning systems, there are still challenges that need to be overcome to leverage its complete potential in education sector. There are several challenges in the implementation of cloud based e-learning. The following are the challenge faced by the cloud e-learning systems[21].

- **Internet connection accessibility:**-It require large amount of bandwidth to transfer an e-learning service so that, the organization have to a high speed broadband connection in order to access an e-learning system from the cloud. The institutions have to provide a sufficient bandwidth to access the e-learning service.

- **Security and Privacy issues: -** The issue of security is the major challenge and the institution have to protect the confidentiality of data going to be transmitted and stored in the equipment offered by cloud service provider. Additionally, strong service level agreement has to be set between cloud user and cloud service provider. The security of cloud and associated privacy concerns, give many organizations pause as they think through their particular cloud computing concerns. Security and privacy concerns include physical security and simple access to facilities and equipment, as well as logical security, industry compliance requirements, auditability, and more. Educators and research communities are concerned about sensitive research data being stored beyond the bounds of their university.
- **Reliability and Trust: -** Cloud outages are well documented and highly publicized, especially when the primary proponents of cloud computing, such as Amazon, Google, Rack space, and others experience such challenges. If the cloud dials tone cannot be assured, such that cloud consumers know that their cloud-enabled resources will always be there for them, and then cloud would be relegated to niche needs where network availability can be ensured.
- **Educational forms and method: -** The traditional class room teaching and learning process was challenged by cloud based e-learning systems. Although an e-learning cloud can be accessed from anywhere and at any time, it cannot replace a teacher. The teachers are playing an important role in the development of such technology and guide them on how to use access and further develop such a technology more and more. The teachers have to participate in developing a new method teaching[22].
- **Educational management rule:-**The management rule is introducing a difficult between educational institution and education through e-learning cloud. They have establish a wide range of management rule with cloud e-learning and have to setup a proper rule in regard to course management rule, content management rule, exam rule, student management rule ,staff workload management rule and so on[22].

2.16 Higher Education Institutions in Ethiopia

We know that education is an essential part of our life, we can change the behavior of the people, develop their skill and knowledge through education. Higher education in Ethiopia is crucial for the production of vital human resources, such as teachers, healthcare professionals, engineers, managers, businessmen, and researchers critical for socio-economic development of a country. Furthermore, higher education is a centre for knowledge and skills creation, adaptation and dissemination. It also plays a significant role in providing relevant and quality community and public services. Higher educational institutions in Ethiopia are changing to

new technology in education to enhance student learning experiences and to produce better learning outcomes and competencies.

The Drawback of E-LearninginEthiopia Higher Education

E-learning in Ethiopian higher educational institutions was implemented and started service in various higher educational institutions particularly in the senior universities. However, there are some drawbacks of using e-learning in Ethiopian higher educational institution. These limitations are listed below as follows:

- **Insufficient personal computer: -** Many of the students does not have personal computer only few student has access to it. Even if, most of student have smart phone they are unable to use e-learning system.
- **Skill on the computer:** - Students have lack of interest and frustration to work on the platform particularly, during at start up sessions due to lack of basic computer skills and experience to e-learning technology and problems related to the digital learning environment. Many of the students entering in the Ethiopian higher education institution do not a knowledge background on how to use computer and increase its usage.
- **Inappropriate power supply:** - Access to the power supply is very important in order to use and run e-learning system. However, currently there is low accessibility of power supply which disrupts the growth of ICT industry in Ethiopia.
- **Internet availability is low: -**Availability of the internet in Ethiopia is low. Even if, in the higher educational institution where internet is accessible, the bandwidth is quite poor and unsuitable for running an e-learning system.
- **High expenditure on infrastructure:-** E-learning system require a high investment on consuming computing resources such as hardware and software on which educational institution is expenses high cost to buy and maintain it.
- **Unsuitable for lab based course:** - Not all courses are suitable to be given through e-learning system but, some course can handled through laboratory and practical field work.

Depending on our questionaries' we are going to analyse the data that we have collected regarding to the challenge of current e-learning system on some Ethiopian public higher educational institutions and the future deployment of e-learning system in the universities. The challenge in providing web based e-learning system for the universities communities was studied through literature review, interview and questionnaires'. In order to do so we had identified several higher education communities such as Student, Lecturer, Administrative staff, PG Student and so on.

From 100% of our respondents, almost all of them was either agreed or strongly agree that there were challenges in delivering e-learning system in the higher educational institutions. Those challenges were occurred due to low internet connection, limited accessibility, and lack of infrastructure, limited scalability, low performance, limited collaboration, and underutilization of resource. The following chart summarizes the responses given by respondents on the reasons for the challenge of web based e-learning service delivery.

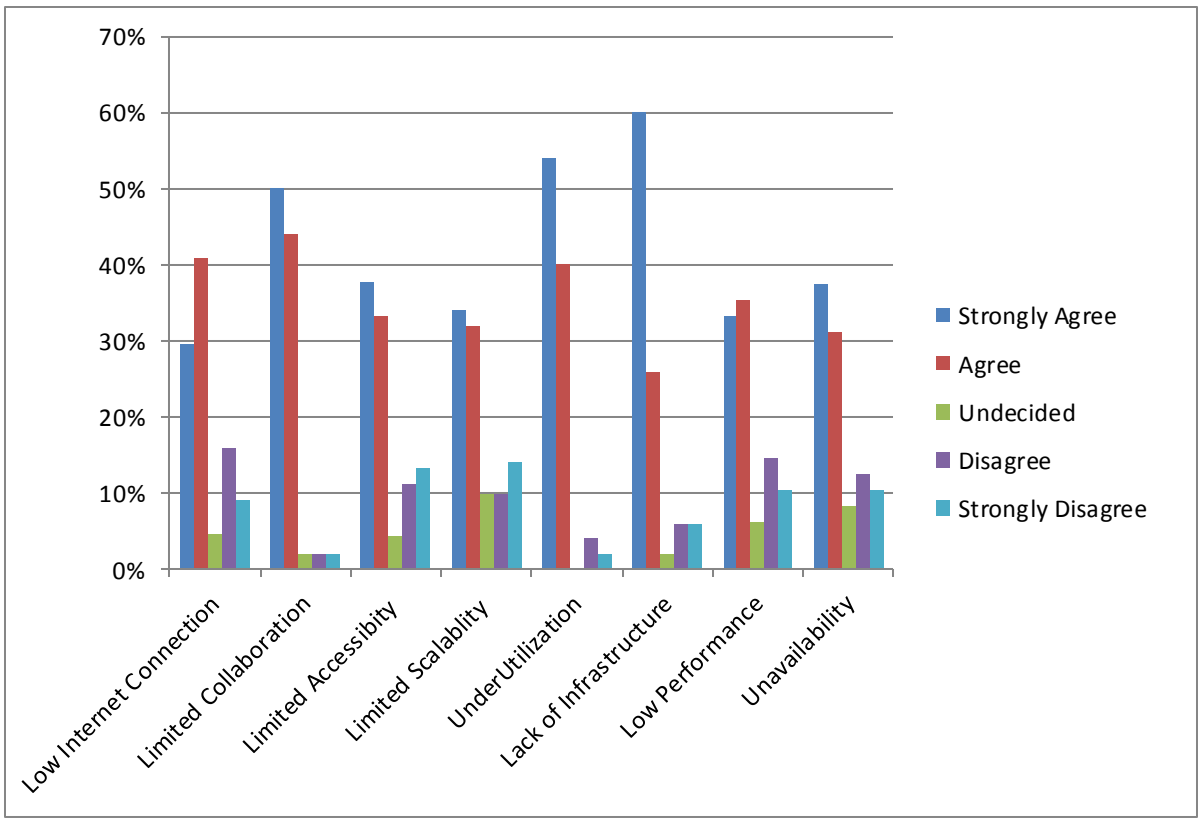

Figure 2-2: Challenge of Current E-learning Service by Respondent

As the chart above indicates the lack of e-learning infrastructure was the highest emphasized issues by many respondents. The other issues which also gained more emphasis were limited collaboration and underutilization of resources.

Once the challenge regarding to the delivery of current web based e-learning services were well known, our respondent were strongly agree or agree that on the different computing solution from the recent technologically development. These are cloud computing, virtual private cloud, multi-cloud and cloud federation are the suggested cloud computing deployment models. Let have look at the summary of suggested computing solution shown in the following chart.

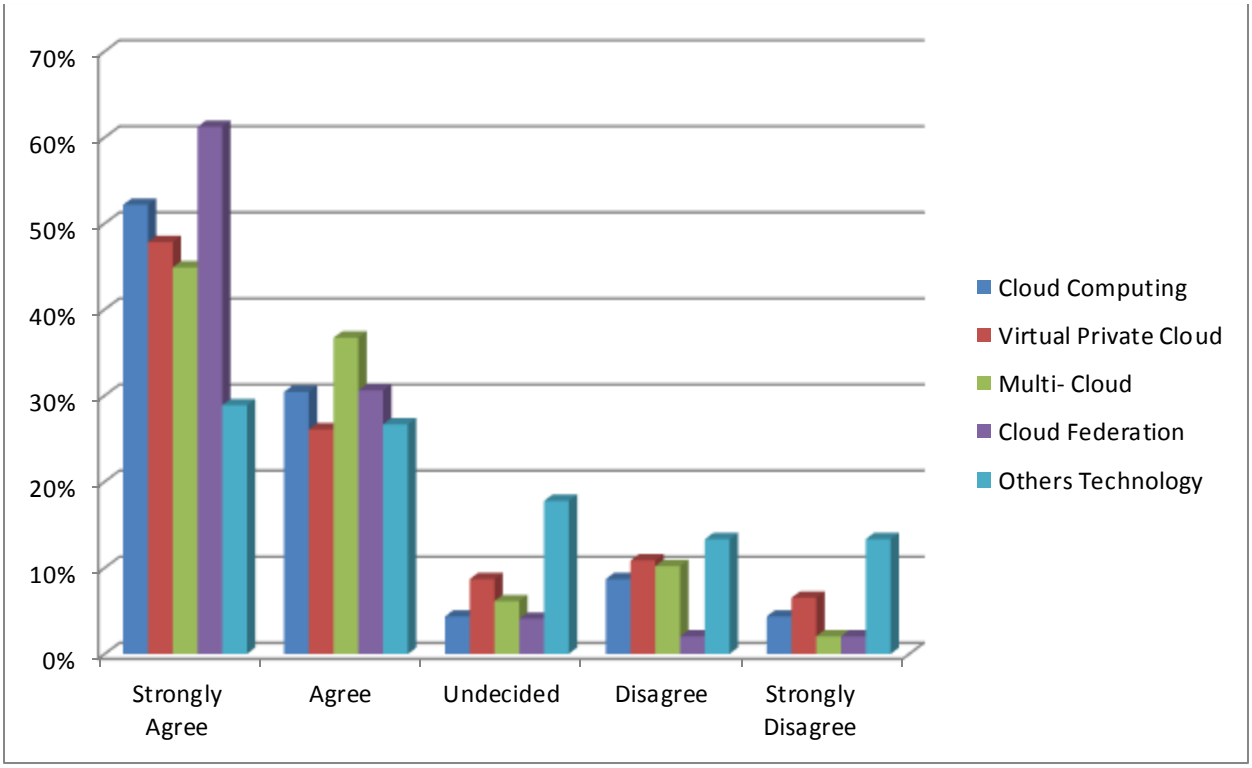

Figure 2-3: Possible Solution Given to Overcome Challenge in E-learning

As we can see from chart shown above cloud federation assured by many respondents can be overwhelmed to solve the challenge raised up from current web based e-learning system in the higher educational institutions.

In addition the respondents told that the current e-learning service delivery especially in new HEIs in Ethiopia is not satisfactory. IT professionals also responded that there was scarcity of resources for the deployment of an e-learning system. Using the federated cloud computing would allow HEIs provide educational resources to their community (i.e. Lecturers, students, researchers) by simply providing end devices that can enable them connect to the cloud to access any kind of resource from a single large federated cloud.

2.17 The Concept of Inter Cloud Computing

Inter-cloud means the "clouds of clouds" which is the interconnection of various clouds[11]. Inter cloud computing provide a benefit to both cloud users as well as cloud providers. For instance, a cloud user can have a benefit of vender lock-in problems when cloud provider is varying its policies which are disturbing its performances. Inter cloud computing helps in exporting service such as workload from cloud one to another cloud provider. It is also give an advantage to cloud providers in such a way that, it can provide sufficient resource at any time so that, cloud users have get resources they needs. In this dynamic world, the

requirement for the technology is not limited and people need further development. Although the cloud computing is the recent technology, it is elastic technology in nature and it is growing rapidly in the field of information technology. The future deployment of cloud computing is the inter cloud which is a federation of cloud consist several clouds. Let us see in the diagram below the evolution of information technology regarding to cloud computing.

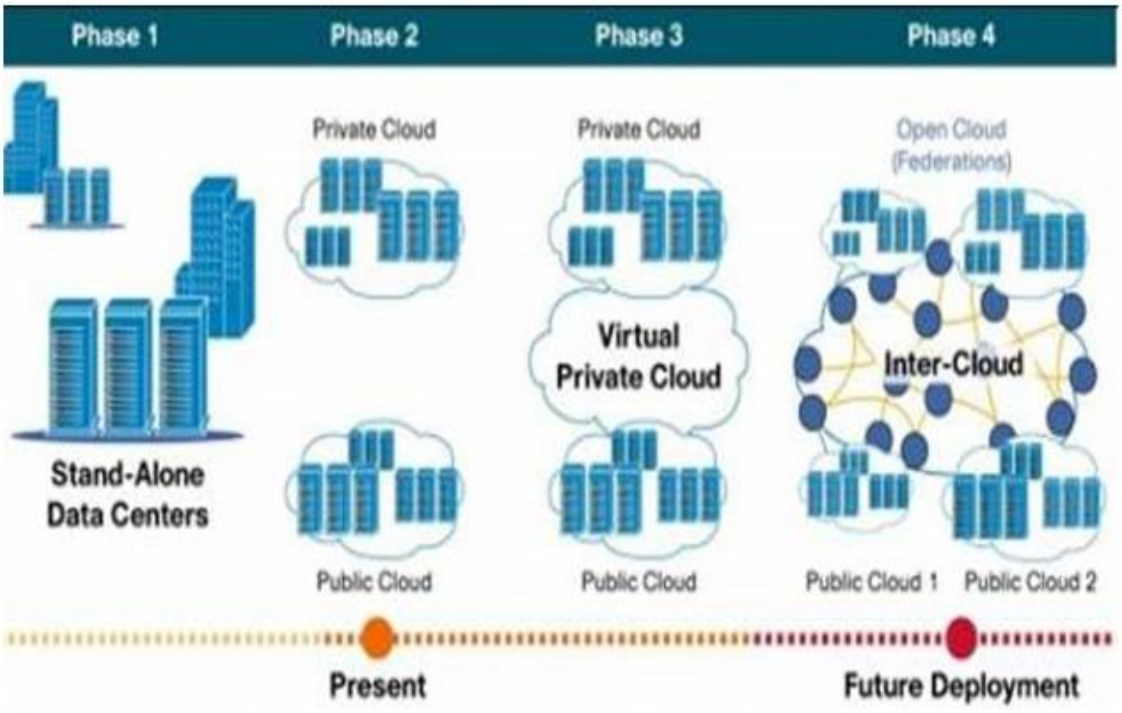

Figure 2-4: Evolution of Cloud Computing[3]

2.18 Classification of Inter Cloud Computing

Inter clouds computingcan be classified into two categories and these are cloud federation and multi cloud.

2.18.1 Federated Cloud

Federated cloudis a combination of various cloud service provider that share their resource voluntarily with each other. One can think of cloud federation as the internet where a user uses the internet or access any kind of the web site through different web browser[11].

[3]https://www.bbvaopenmind.com/en/cloud-clouds-intercloud/

2.18.2 Multi Cloud

Multi cloud is used to interconnect multiple independent cloud service providers that do not voluntarily share their resource with each other. A middleware or a software API is required in order to interconnect multiple separated cloud. One can think of multi-cloud as social networking in which we can't involve and use different social network service at the same time because they are separated from one another. The user may be member of many social networks but they are separated and do not have interoperability among them. To do so, we need to merge different social network through some standardized middleware or an API[11].

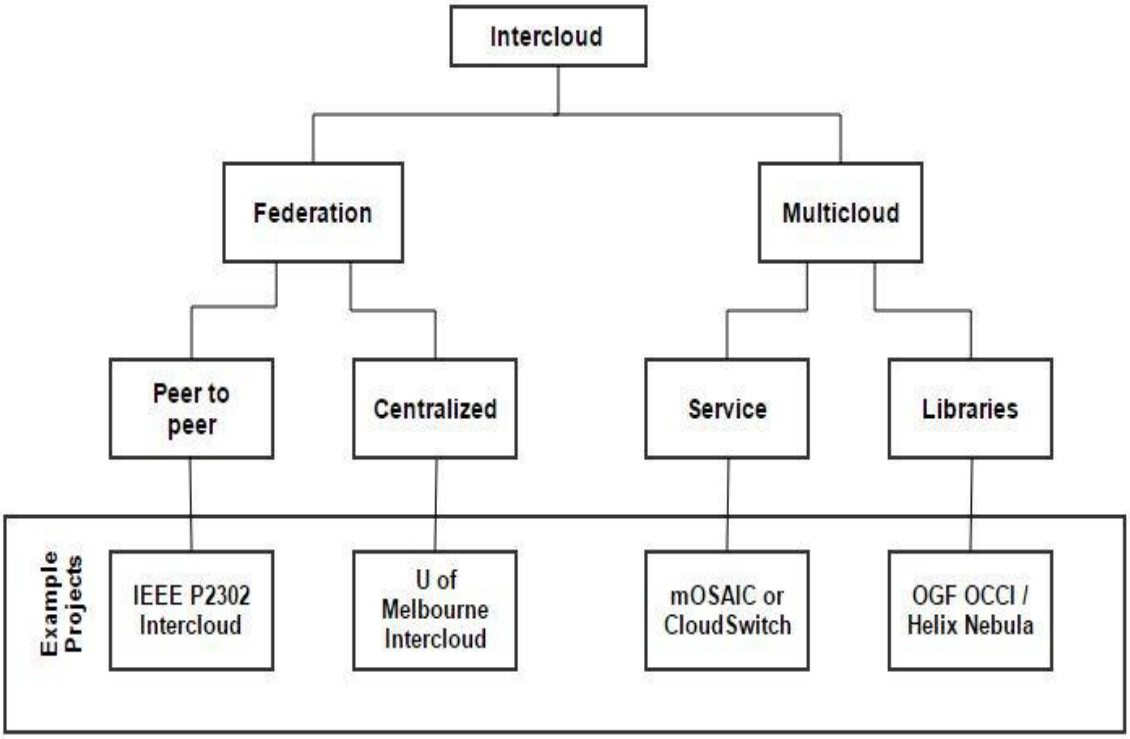

Figure 2-5: Classification of Inter Cloud [11]

2.19 The Concepts of Cloud Federation

As we try to describe the classification of inter cloud computing, we have discuss the concept of inter cloud. Cloud federation is one of the futures of cloud computing which can be used to interconnect several clouds under one single huge cloud having tremendous amount resources.

When we talk about federated cloud different people have different meaning for cloud federation. We can define cloud federation as the concept of bringing different service offered by several cloud providers under a single cloud environment for the end user consumption[11].

Cloud Federation is defined as "practice of interconnecting the cloud computing environmentsof two or more service providers for the purpose of load balancing traffic and accommodating spikes in demand"[4].

A federated cloud is one of the future cloud computing features. When we look at federated cloud in higher education institution, it provides a major role in unifying different higher education institution in order to share their resource in particularly, the e-learning infrastructure resources for improving the teaching and learning process.

Federated cloud is one categories of inter-cloud which is "cloud of cloud" and it can be classified into centralized cloud and peer to peer cloud.

Nowadays, we come to stage where it is no single resource consumption in cloud computing technologies could be happen rather, there is a consumption of resource from federated datacenter. The main factor for the cloud federation can be described in terms cloud provider side as well as customer side. The factor in the cloud providers is that it can help scaling up and this is to mean that the capacity augmentation. Right now, in this dynamic world if there is a need for the capacity definitely, cloud provider can add additionally capacity to maximize the resource and revenues. Another method of looking at the capacity augmentation is the capacity utilization in terms of optimum capacity utilization.

Suppose we have two e-learning cloud providers and if one cloud provider is usually not utilizing the capacity and the other cloud provider who actually needs more capacity then, the capacity can be additionally capacity that would be given to another cloud provider by which the actually be optimal utilization for both providers.

Cloud federation enhances the cloud user value for and enables offering IT service as a product. The model of cloud federation supports in delivering services request across cloud service delivery model such as IaaS, PaaS, SaaS and central cloud broker which handles the request comes from cloud users. If a cloud task on specific cloud environment is high in requesting the service delivered by that large single cloud datacenter and service is not enough then, it can satisfy the request through the nearest cloud datacenter. In other words, if a user request some application or resource in particular cloud then, it can get the resource or service from another cloud through federation. The following figure illustrates the cloud federation between two clouds (cloud A andB).

[4]http://searchtelecom.techtarget.com/definition/cloud-federation

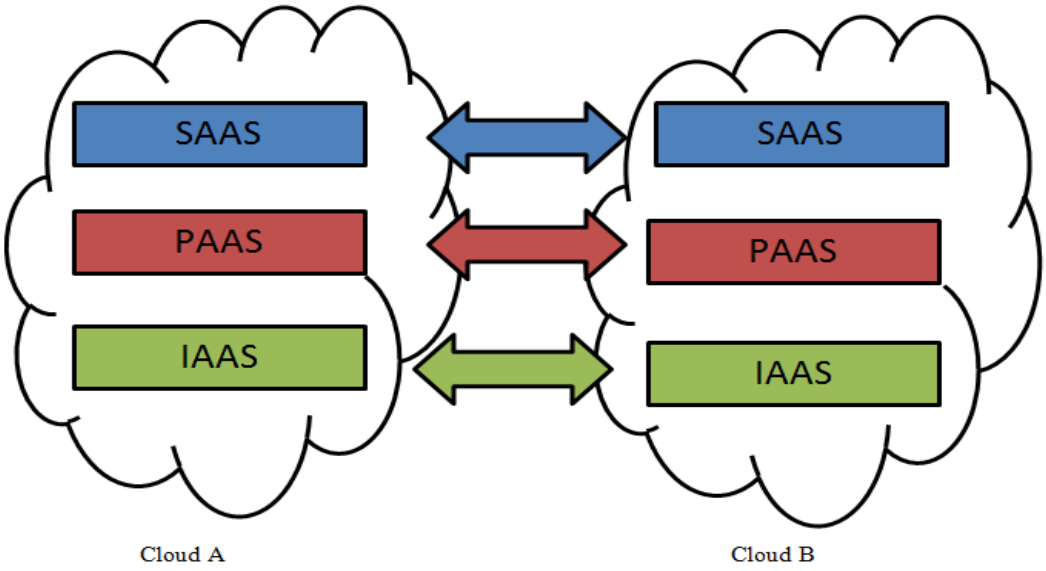

Figure 2-6: Cloud Federation between Two Clouds[23]

As we can see in the above figure shows the federation of different cloud that has different capacity are interrelated and working together. In these two clouds such as cloud A and cloud B, the federation is created along each service delivery layer such as software as service, platform as service, and infrastructure as service layers. However, in our proposed solution we are limited to the infrastructure as a service which discuss about allocation of virtual machine to various hosts in several cloud service provider.

2.20 Benefit of Cloud Federation

There are several advantage provided by cloud federation for the organization. The benefit from cloud provider point of view, the cloud federation is beneficial in maximizing the income of an organization and optimization of their resource whereas; from the perspective of customer side, it is important in providing resource in cost-effective and efficient manner as well as solving the vendor-lock in problems. In addition, the customer needs choose of service. The end users have selected the cloud service they need from various cloud service provider from a single federated cloud environment[24].

In generally, here are some of the benefits of cloud federation.

- Cloud federation increases the cost effectiveness and power efficiency.
- In cloud federation there was no a single point of failure, the resource were distributed across several geographical dispersed datacenter.

- In cloud federation the cloud user were not depend on only a single cloud provider rather , they acquire from multiple heterogeneous datacenter based on their demand.
- Cloud federation improves load balancing across multiple datacenter.
- Cloud federation provide unlimited amount of resources that integrated from several datacenter to the requested users.
- Cloud federation was providing high resource availability.

2.21 Challenge of Cloud Federation

Cloud federation have many challenge related to such interoperability issue, security issue. From customer side of view, the end user is interoperable to various resources provided by several cloud providers. We know that the customer are looking for different resource in various cloud providers and combining them together. Let have look at some basic challenge of cloud federation[24].

- Selection of cloud provider: - selection of best cloud provider from cloud federation is difficult tasks for cloud user. Several cloud providers has various attribute and collection of services. So, cloud user should look at some characteristics or parameters of cloud provider such as cost, performance, response time, geographical location, reliability of the cloud provider etc.
- Mapping service to the required resources: - Mapping service to the required resource is difficult because, complicity and unwillingness in the attribute of resources.In federated environment one provider are good at one service and other are very good at other services.
- Localization: - It refers to that where service should be reside and be located. It is very difficult for cloud provider to serve their end user from very far away. So, it should be closing as much as possible to serve the end user.
- Service Level Agreement and security: - Lack service level agreement and security among cloud service provider bring a negative impact on management, monitoring of service in the federated cloud.
- Heterogeneity of platforms: - It is difficult to cloud user to choose the suitable platform to deploy their workload.

2.22 Approach of Cloud Federation

According to the authors [25] describe several approach of cloud federation. The following are the cloud federation approach and these are:

I. Centralized Approach
II. Decentralized Approach
III. Hierarchical Approach

2.22.1 Centralized Approach

It is a centralized cloud federation inwhich a single object such as single cloud broker is placed centrally to perform resource sharing and allocation. In this approach there is only one central entity which manages and control several clouds. It is shown as the following figure below.

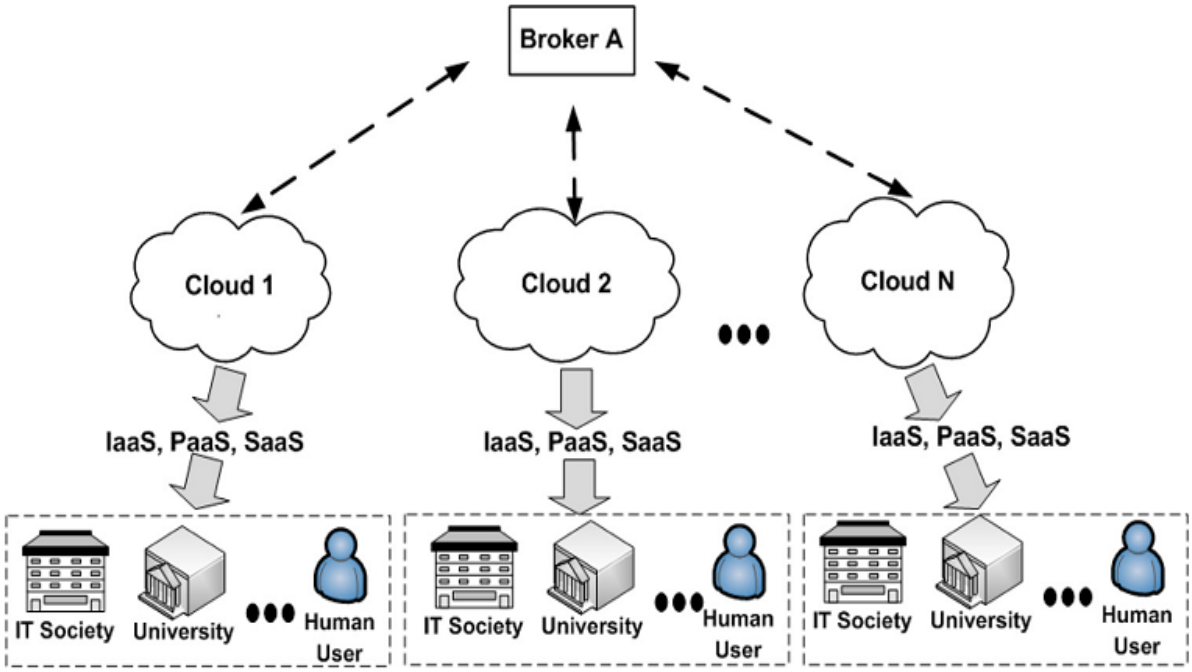

Figure 2-7: Centralized Cloud Federation Approach [25]

2.22.2 Decentralized Approach

In case of decentralized approach there is no central third party entities rather each and every cloud could directly communicated with each other. It is a type of peer to peer cloud federationin which each independent cloud able to communicate and share their resource directly without any third party in between them. It is shown as the following figure below.

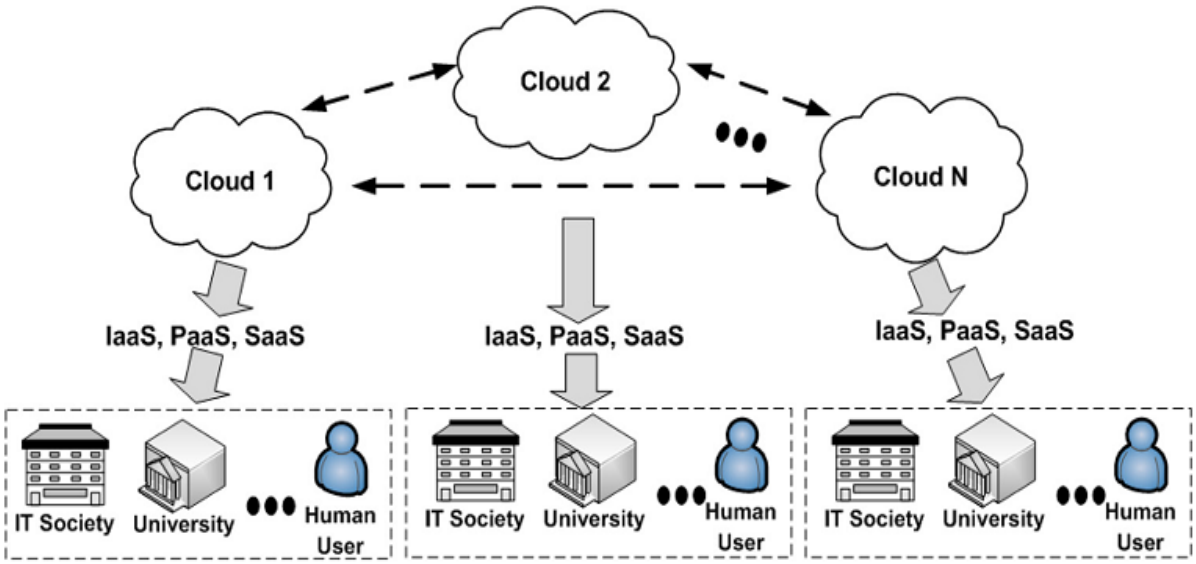

Figure 2-8: Decentralized Cloud Federation Approaches [25]

2.22.3 Hierarchical Approach

In this approach several cloud are connected together through a number cloud broker in such a way that a cloud is connected to one of the cloud broker and again a broker is connected to another cloud broker in order to contact with the other clouds. The figure is illustrated as follows.

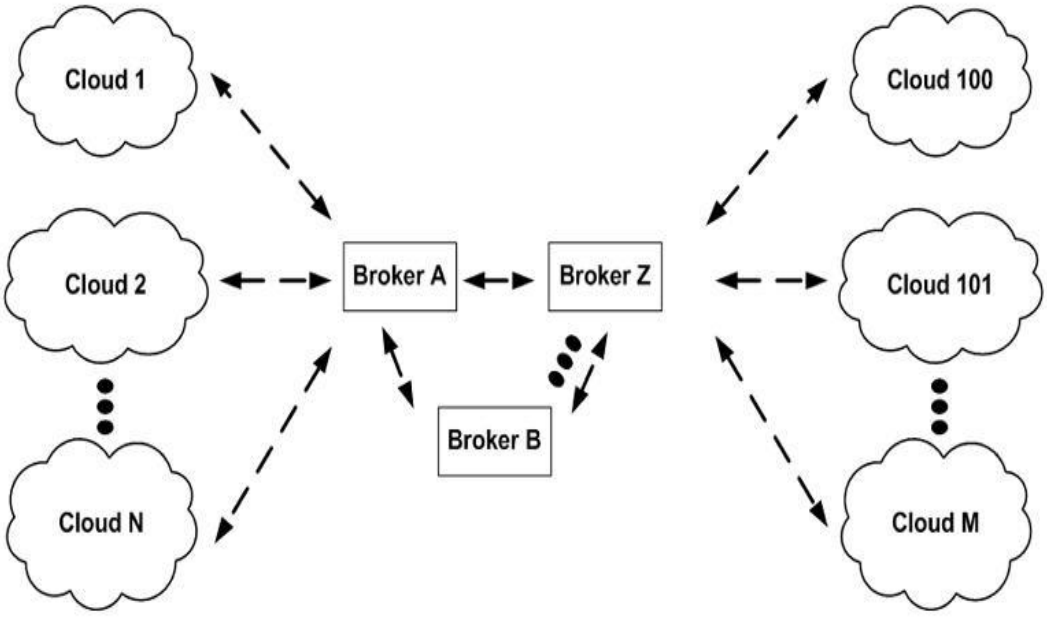

Figure 2-9: Hierarchical Cloud Federation Approach [25]

Based on the above cloud federation approach proposed by[25] our proposed solution follows the centralized cloud federation approach in which we can create a single

federated broker which would control and inter connects several data centers in order to facilitate resource allocation across multiple datacenter.

2.23 Related works

We reviewed the literature and found that many articles which share out with the subject areas of our work. These research articles described about the E-Learning and cloud based E-Learning issues in cloud computing and federated cloud. The following articles provided a strong theoretical framework for our thesis.

According to Educase, a reviewshows that nearly all institutions had a major interest in e-learning systems. "Online courses were ubiquitous, with over 80% of institutions offering at least several courses online and more than half offering a significant number of courses online".

Let us review some of our literature we had found from different scholars.

In the study ofSulistio[26] Hochschule Furtwangler University, Germany establishes CloudIA (Cloud Infrastructure and Application) framework to build private cloud for the purpose of running e-Science and e-Learning applications in university. In this framework, Cloud Management System (CMS) was used with different layers that specify the components used in building private cloud. It provides SCP (Server Container Platform) as Platform as a service to the students of the university.

The research article on "Cloud computing a new business paradigm for E-Learning" [21]which expresses the cloud based e-learning, benefits of cloud based e-learning, and the practical challenges and solution on implementation of this technology. It explains about the traditional web e-learning method and this mode of education was not capable to grow as a change of e-learning demand with time and development of technology. And in traditional web e-learning the system construction and maintenance were found inside the educational organizations so that, there was a problem inside it, a lot of capital was needed, human resource, underutilization of resource and so on.

In the article entitled as "From Monolithic Systems to a Federated E-Learning Cloud System" the Lin, Luo[27] proposed on the field of cloud computing to extend the capacity of e-learning system and model a federated cloud to support an e-learning system service partition. The researcher studied on how to migrate monolithic e-learning system to the cloud computing paradigm. It providea generally architecture of virtualization management layer in

order to balance the load, manage and maintain the hardware resource and networks. In additions Lin, Luo [27] assumes the usage hadoop distributed file system in order to provide storage service to variety of server machine and file of system data. This assumption was simplifying data coherence issue, high throughput data access and availability issues. One of the limitation of using this kind distributed file is unable to support small amount resources and also limited in VM creation and allocation of infrastructural resources.

The integration of web based e-learning and cloud computing was forming cloud based e-learning system. This can be done by combing e-learning process with cloud computing process through software engineering concepts[28]. It identifies that different web based e-learning platform and differentiates between Moodle and blackboard. It proposes a cloud Moodle services as tool for e-learning through cloud computing to improve the performance of the existing e-learning. The integration was based on incorporating of information, processes, applications and human resources (students, teachers and other participants) in existing e-learning system by enabling the Moodle, the Open LDAP directory for management of user accounts, and the Open Nebula cloud computing platform for management of cloud computing infrastructure[28]. To build and manage this kind of process consumes a huge amount of costs. It has limitation or challenge in optimizing resource allocations and controlling cost.

Many organizations like higher educational institution needs the integration of their existing system with new technologies such cloud computing or cloud federation. According toPedro Lopes andPereira[29]an academic cloud federation were proposed to solve the cloud integration issue among several educational institutions such as universities, poly technics and others. In this specific research studies, they were going to integrate several private cloud found in different institutions to a form a single hybrid cloud infrastructure in higher educational institutions. They were implemented using an open stack platform with in two months. The model provides the opportunity of the cloud federation or its component clouds, each autonomously, to be inter connect with considered partners. This approach opens pathways to adaptability and elasticity in the cloud federation. As organizations linked to togetherless number of resources areexpected to be shared [29]. The proposed model consists of each component and they were interconnected to bring about an academic cloud federation. The following figure was the model of proposed cloud federation.

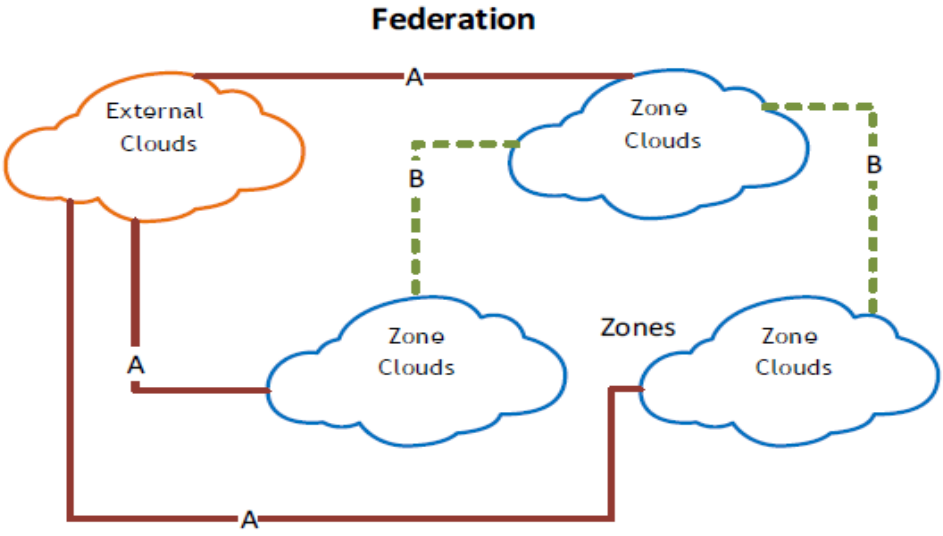

Figure 2-10: Proposed Model[29]

According to [30] proposes academic cloud framework in order to provide a new era in e-learning. This framework addresses the services and deployment of cloud in a new dimension and each layer specifies the essential components needed to construct an academic cloud in a university. They also describe the advantage of using cloud computing such as accessing the file storages, databases, educational resources, research applications and reducing higher educational institution IT complexity and cost in the Ethiopian university. These proposed academic framework presented by [30] had six distinct layers in shown in the following figure below.

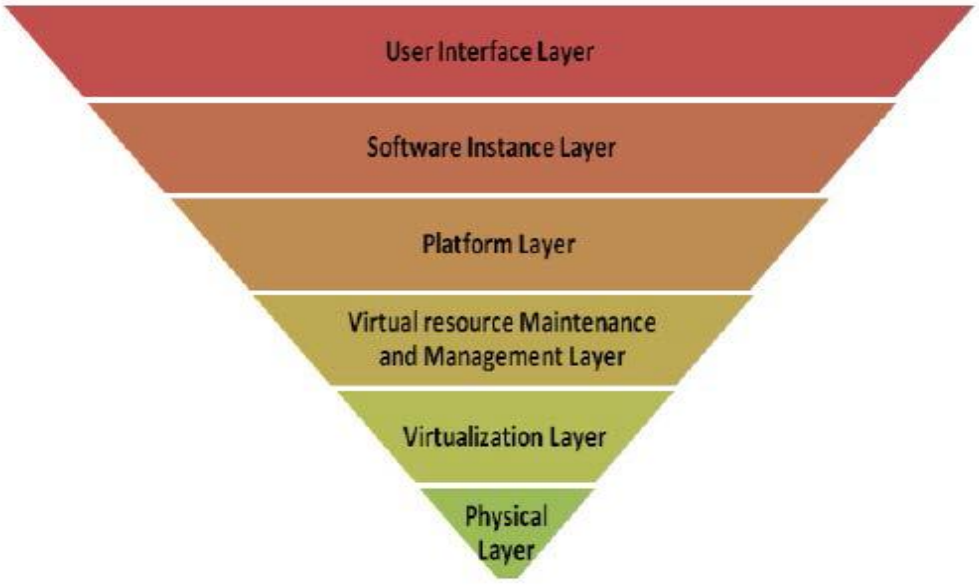

Figure 2-11: Layers of Academic Cloud Framework [30]

We know that recently, the Ethiopian ministry of education had funded a project to establish a national research and education network which provide a computer network for

interconnecting a research and educational institution in order to facilitate the exchange of information for research and teaching purposes. The interconnection of this network was established through fibre optics line and connected to an Ethiopian telecom as a backbone.

The major drawback of these projects was that the costs extremely high, it require a trained IT professional for regularly maintenance and supports. By applying a federated cloud model to interconnect higher education learning resource the challenge with national research and educational would be solved easily.

As we had been discussing on the above literature review, we had found a lot things such as scarcity infrastructural resources, lack of collaboration across several higher educational institutions.Ourproposed solution was focusing on build up infrastructure resource allocation in the federated cloud e-learning for in the higher educational institutions. This can brought an integration of e-learning system resource from various institutions into single centralized infrastructural resources in which all the institutions were equally used, participate and collaborated among each other's and accessed e-learning infrastructure resource based on their demand. Therefore, according to these literature reviews, we found that none the authors were proposed allocating of resource in the cloud federation for educational institutions.

3 Chapter Three: Research Methodology

3.1 Research Method

Methodology of the research is a way to scientifically solve the research problem. It tell us the way we are going to solve the problem. The methodology for a research incorporates that *"*what kind*"* of study that is also being used, (is the research qualitative, quantitative or both) among other things.

In order to solve the problems the researcher find out the related papers regarding to the area of cloud based e-learning system and cloud computing, discuss on the issue of current web based e-learning system with different IT expert, studying intensively literature review which wasdescribed in the previous chapter. The next chapters were all about detailed study in the area of e-learning; cloud based e-learning and federated cloud as well as proposing framework and prototype for solving the problems. Then, implementing the model federated cloud in order to solve resource allocation according to the request comes from user.

We have using several tools approach for design of our research. For the purpose building up frameworks, flowchartand documentations,we were using Adobe Photoshop CS6, Edraw Max and MS -Office. To implement our proposed framework we weregoing to select open source cloud computing tools in the next chapter.

3.2 Research Design

The most important way to identify the research design was to differentiate between qualitative and quantitative studies. In this research we had been used mixed methodology that was both qualitative and quantitative research.

A quantitative research can certainly generate statistical proof through methods like a survey research or quantitative questionnaires. A quantitative research deals with numerical information. Quantitative research method depends on statistics, which was precise and could be proved regularly. However, it is not appropriate to explain the relationship between the objects[31].

Qualitative research contributes to discovery and theory-building [31] which was being attempted by this research with respect to a cloud based system. The principal advantage of qualitative research was the researcher gains more detailed and rich data in the form of comprehensive written descriptions or figures. Again qualitative research method

wasproviding description of the relationship between the objects. In generally, this research involved towards both qualitative and quantitative studies.

3.3 Data Collection

This research emphasis on building the federated cloud based e-learning resource allocation in higher educational institutions. Based on the specific objective of the research, the research strategy was descriptive and used a research design such as literature review questionnaires, interview and document observations. The research design used in order to gather data at a particular point in time with the intention of describing the nature of existing conditions or identifying standards against which existing conditions can be compared, or determining the relationships that exist between specific events.

The study population was personnel from ministry of education, academic staff, administrative officers and student from some nearest institution to Adama Science and Technology University. In order to collect data about the current working e-learning systems in the universities the researchers was used literature review, observation, interview and questionnaires.

Literature review was considered to be information that already presented by another researcher. In that way, research books, conference paper, reports, journal articles, electronic document and websites were reviewed in order to understand the research work particularly and our research area in general.

In addition we were also observing and exploring how the traditional and existing e-learning infrastructure was installed and working, that helps to examine the benefit and challenge of the existing e-learning system.

The interview sessions and questionnaire were conducted side by side with ICT staff and e-learning administrator with threeEthiopian public higher educational institutions such as Addis Ababa, Adama Science and Technology and Hawasa univeristies. The interview used as an input for the development of questionnaire. Finally, a questionnaire survey was conducted. The questionnaire contains choices or close-ended questions.

The purpose of the questionnaire was:

- To had knowledge of on the current existing e-learning system working in the Ethiopian higher educational institutions.
- To identify where to start and how to start this research

- To understand Ethiopian educational ministry opinion towards the system recommended in this research.

The questionnaire was divided into two parts. The first part was about the challenge of current e-learning system used in a various higher educational institutions. In this part, it deals with the limitation of current e-learning system and overall use of e-learning services in the higher educational institution as well as the consumption of resource through e-learning system and how the end user wasaccessing it and so on. The second part wasfunctionality of cloud computing models to solve the existing system challenges and suggested computing solution in the future deployment of e-learning system.

3.4 Data Analysis

In this section, the findings from the observation, interview, documents and questionnaire survey were systematically analysed.

The quantitative data collected mainly through questionnaire from the users answers were used for analysis by using Ms-Excel. Analysis was made for data and percentages were used to analyse the survey data. Charts were used for further analysis.

Qualitative data were analysed by using cloud simulation tools. Most of the qualitative data were input to the cloud technology and were compared with each other and answers from highly qualified and more experienced IT professionals were taken as bases for all other answers.

The data analysis werefurther discussed in detail in chapter six where the implementation result of proposed model were analysed and the result can be generated by using cloud computing tools.

3.5 Validity and Reliability of data

In order to make sure the reliability and validity of data, we were going to do the following things.

- Comparing and contrasting the cloud federation with non-federated cloud to identify the reliability and validity.
- Our federated cloud was more valid, reliable and provides a better performance as well compared to with non-federated cloud.
- The consistency of data collected in different methods.

- Making sure the questionnaire to be collected with the presence of IT staffs of the five higher educational institutions, some of them had already introduced e-learning system and others were not started yet and the researcher himself to make the questions more clear.

Based on five Ethiopian public higher educational institutions e-learning administrator and IT staff and other member had been represented. Consequently, data collected from different university professional of IT staff had shown high level of consistency. On the other hand, to make the IT staffs give more attention when they fill in the questionnaire and participating in person during the questionnaire was filled.

4 Chapter Four: Selection of Open Source Cloud Computing Tools and Service Providers

In this chapter we were going to describe and select open source cloud computing tools for our implementation in the next chapter. We can also select and explain different cloud service providerand the service they going to provide for the user of a cloud.

4.1 Selection Open Source Cloud Computing Tools

We had selected a cloud simulation tools as well as cloud computing platform tools. The researcher uses simulation tool instead of cloud computing platform. Let us have look at the diagram below which describe the overall cloud computing tool selection.

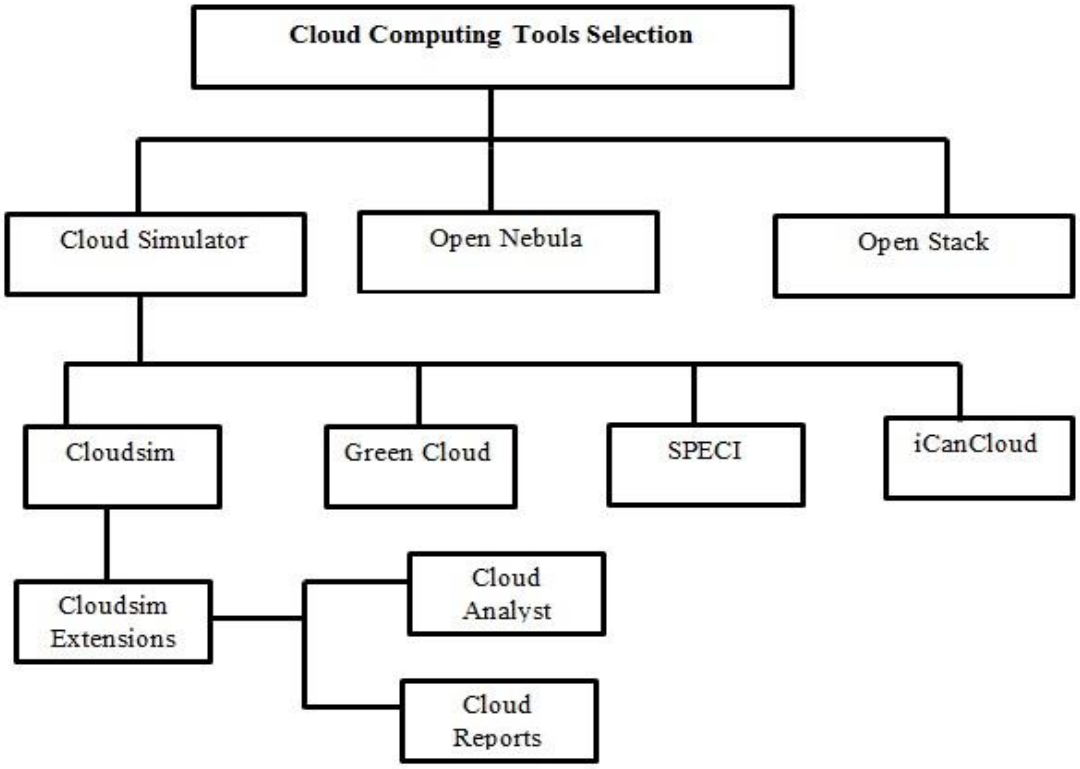

Figure 4-1: Cloud Computing Tool Selection

The benefit of simulation tool instead of practically running on the real cloud environment is that:-

- It opens up the possibility of evaluating a supposition.

- We can check weather our assumption is working or not.
- Before implementing the cloud application in real environment, the simulation give us a test environment in which, we can test whether it is running properly or not.
- In case of cloud computing, a simulation can helps us in giving repeatable and controllable environment as well as if there are any bottleneck or challenge in the algorithm then, we can find this method of simulation so that, we cannot build a whole cloud environment which is very cost to build and time consuming. Therefore, the simulation helps us to find the limitation in short period of time. We can have also different workload makes such as gives various number of tasks, develop several kind of virtual machine and develop their mapping according to the algorithm. The simulation is free of cost thus; we can just running the simulation on the laptop or desktop machine. We had proposed at least three tools in order to show the implementation of cloud federation. Let us compare the tools we selected in table shown as below.

Table 4-1: Comparison among Selected Cloud Computing Tools

No	Metrics	Cloud Simulator	Open Nebula	Open stack
1	**Source Code**	Open source	Fully open source	Fully open-source
2	**Deployment**	IDE or platform	Real Cloud	Real Cloud
3	**Component**	Toolkit	Product	Product
4	**Focus**	Both user and cloud provider	Interest of user needs	Interest of provider effort
5	**Flexibility**	More flexible than all	Less flexible	More flexible than open nebula
6	**Efficiency**	More efficient	Less efficient	More efficient than Open nebula

4.1.1 Cloud Simulation

Cloud simulation is a discipline and way of making a model to develop a real system, it is used to evaluate and test cloud environment. That helps to know and recognize the characteristics of the system environment or assessing several approaches [32] . Cloud

simulators are used to evaluate the performance of the cloud computing environment. There were lot cloud simulation tools, for time being we were going to discuss some of cloud simulator that was used for running cloud computing and these can be listed as follows.

- CloudSim
- GreenCloud
- SPECI (Simulation Program for Elastic Cloud Infrastructures)
- iCan Cloud

Among the above cloud simulation tools the researcher preferred to use cloudsim to simulate and model resource allocation in the cloud federation datacentre. Cloudsim is basically a toolkit or we can say it is a library of java classes for simulation of cloud computing scenarios.

- **CloudSim**

Cloudsim is an open source cloud computing simulator tools which gives us the test environment. It supports a simulation of large scale cloud computing infrastructure including the datacenter on a single physical computing node. It offers the availability of virtualization engine which aids in creation and management of multiple independent and co-hosted virtual machines on a datacenter node. We know that cloudsim does not have graphical user interface however, it has an extension which support graphical user interface such Cloud Analyst, Cloud Report and other. Cloudsim composed of multi-layer and support simulation and modeling of virtualized datacenter, federated datacenter, cloud services such as IaaS, PaaS and SaaS. We hadselected cloudsim as our best simulator of all simulation tools.

Let us now, compare among cloudsim, Cloud Analyst and Cloud Reports in following table below[33].

Table 4-2: Comparing Cloud Simulation Tools

Comparison Metrics	**Cloud Simulator**		
	Cloudsim	Cloud Analyst	Cloud Reports
Scalability	High	Medium	Medium
Repeatability	High	High	High
Reliability	High	High	High
Flexibility	High	Medium	Medium
Accuracy	High	High	High
Efficiency	High	Medium	Medium

The following figure shows the architecture of cloudsim toolkit by[11]

.

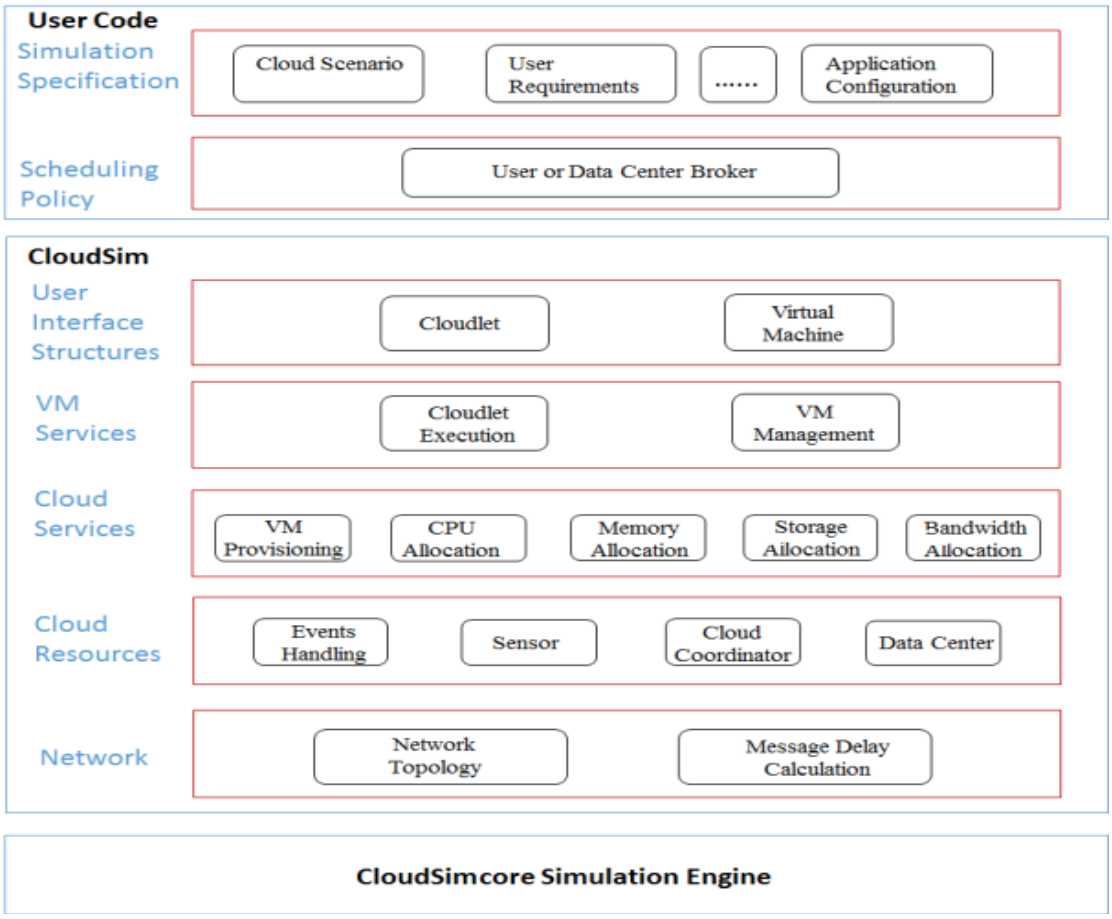

Figure 4-2: Architecture of Cloudsim[11].

➢ Green Cloud

We know that tremendous amount energy is consumed by large cloud computing datacentre infrastructures such as server, network and communication line. Green cloud is a cloud simulator that is used to simulate energy-aware cloud computing data centres and it can be used to monitor, resource allocation, workload scheduling and optimization of communication protocols and infrastructures[33].

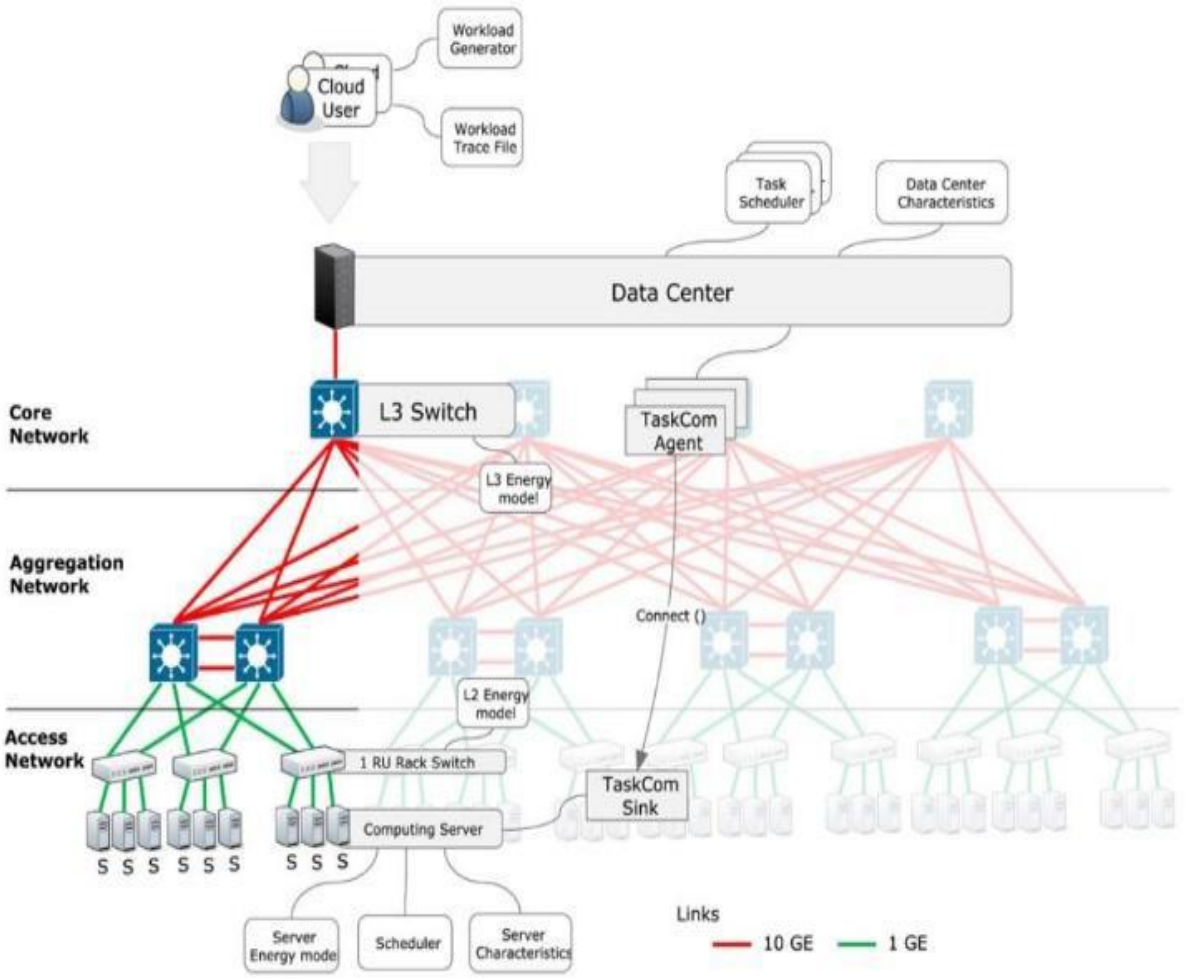

Figure 4-3: Architecture of Green Cloud Simulator[33]

➢ **SPECI**

It is Simulation Program for Elastic Cloud Infrastructures and it is a cloud simulator which allows investigation aspects of scaling the performance and the behaviours of future datacentres[33].

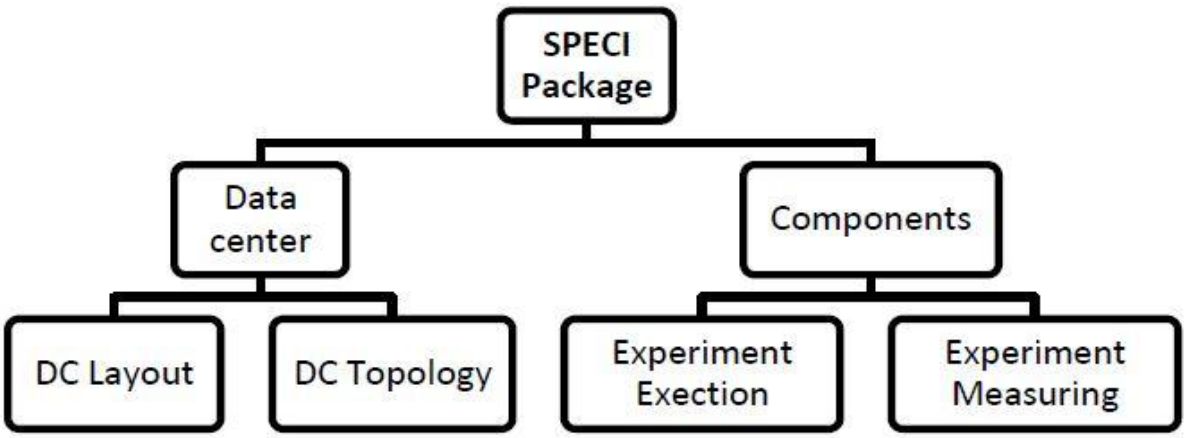

Figure 4-4: SPECI Package[33]

➢ **iCan Cloud**

iCanCloudis also a cloud simulator tool for simulating high performanceapplications on large network. This simulator is established based on SIMCAN (a simulation tool to analyse high performance I/O architectures). In this simulator, no need to modify the code to test several model[33].

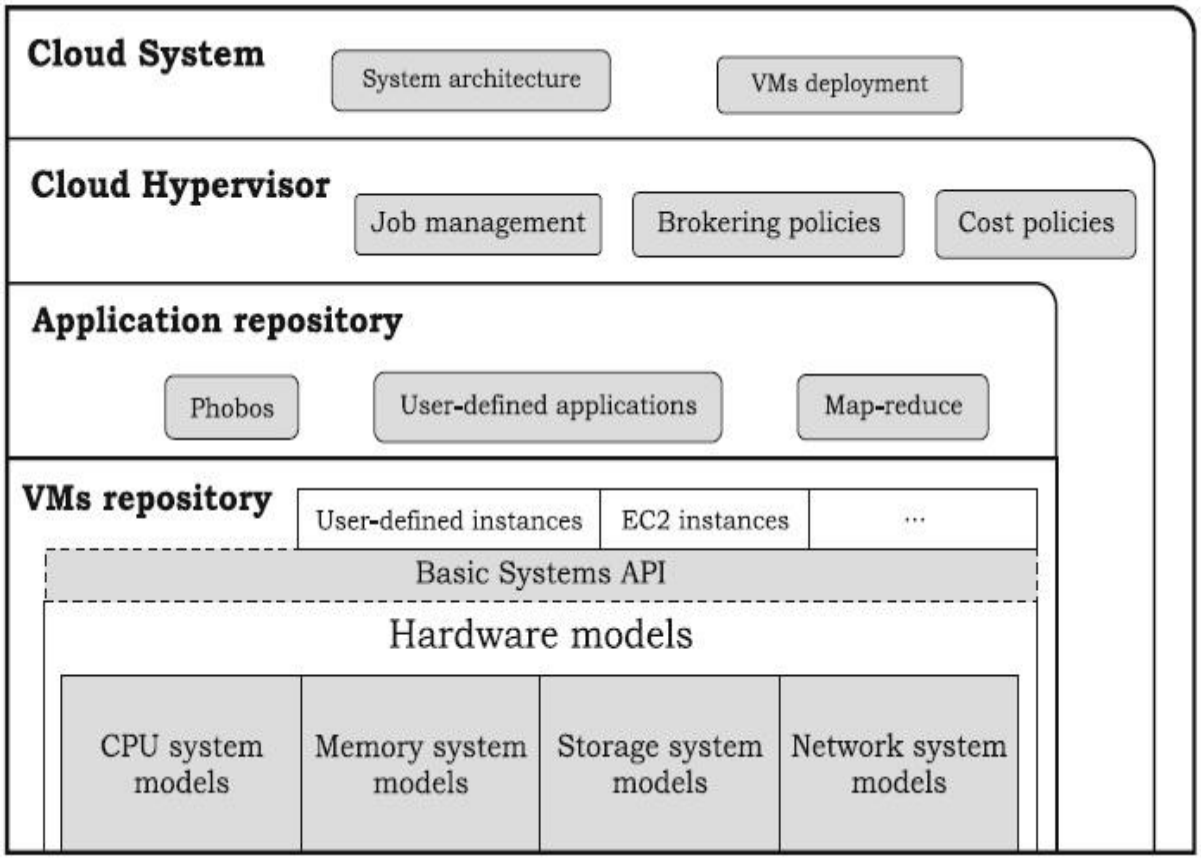

Figure 4-5: Architecture of iCanCloud[33]

Summary of cloud simulator comparison

The summaries of above cloud simulation tools shown as following table.

Table 4-3: Comparison among Cloud Simulator

Cloud Simulator	Cloudsim	Green Cloud	SPECI	iCanCloud
GUI Support	Limited (Cloud Analyst)	Limited (Via Nam)	Limited	GUI Support
Platform	Gridsim	NS2	Simkit	SIMCAN
Language	Java	C++	Java	C++,OMNET
Support of TCP/IP	None	Full TCP/IP	None	None

Software or Hardware	Software	Software	Software	Software
Availability	Open Source	Open Source	Open Source	Open Source

4.1.2 Open Nebula

Open Nebula has a flexible component-based structure and includes several predefined drivers for information management (monitoring), image and storage management, as well as to support several hypervisors. In addition to the numerous private cloud drivers, Open Nebula also integrates drivers for AmazonEC2 and elastic hosts, and can be easily extended to support other cloud providers. With its support for EC2, Open Nebula can be configured to use Amazon's infrastructure for cloud bursting, or use other EC2 compatible systems. An Open Nebula cloud typically consists of a front-end node for administration purposes (i.e. for managing hosts and images), as well as of several cluster nodes to execute the VM images. The hosts are controlled by the front-end either via command-line tools, or via programming interfaces [34].

There are several services provided by the Open Nebula[5]. The major services given by Open Nebula are summarized in the following table.

Table 4-4: Open Nebula Services

No	Customer Service Given By Open Nebula	Functionalities
1.	Image Catalogs	Catalogs are data stores. It allows storing disk images in catalogs, which can be then used to define vms or shared with other users.
2.	Network Catalogs	Virtual networks can be structured in network catalogs, and used to interconnect virtual machines.
3.	Virtual Machine Catalogs	Allows registering virtual machine definitions in the system, to be instantiated later as virtual machine instances.
4.	Virtual Resource Control And Monitoring	Control and monitoring lifecycle of the virtual machine instances.

[5] www.opennebula.org

5.	Multi-Tier Cloud Application Control And Monitoring	It allows defining, executing and managing multi-tiered elastic applications.
Service Provided by the Open Nebula to the Cloud Operator		
6.	Users And Groups	It provides users and group's management, resource allocation, and resource quota management and limit computing, storage and networking utilization.
7.	Virtualization	Controlling the Virtual Machines and multiple hypervisors in the same cloud infrastructure.
8.	Security	Authentication and authorization mechanisms identify a authorize users.
9.	High Availability	Provide easy to use and cost-effective failover solutions.
Service Provided by the Open Nebula to the Cloud Integrator		
10.	Modular And Extensible Architecture	It provides customizable plug-ins for integration with any third-party data centre service
11.	API For Integration	It offers higher level tools such as billing, self-service portals.
12.	Sunstone Server Custom Routes	It allows extending the sunstone server.
13.	Hook Manager	It provides administration scripts for VM state change.

The conceptual architecture of Open Nebula which assume classical cluster architecture with a front-end, and a number of host's resource like virtual machine are executed. The function of the Open Nebula component such as Front-end used to execute the service in the Open Nebula, data store used to store the image of virtual machine, host were used to provide virtual machine and physical network were used to interconnect the host with front–end.

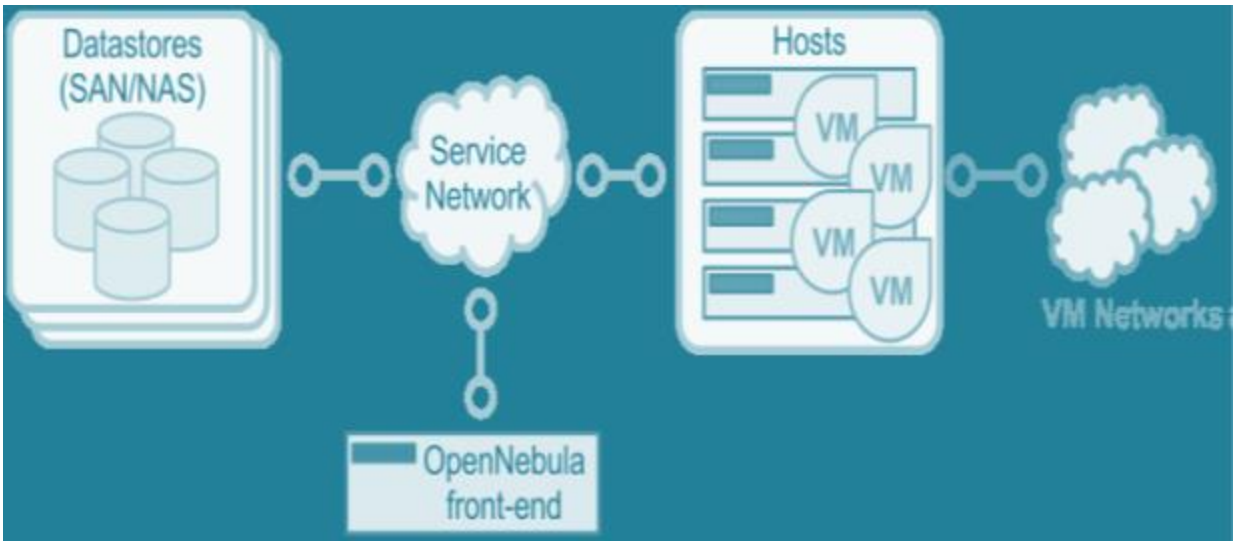

Figure 4-6: Conceptual Architecture of Open Nebula [6]

4.1.3 Open Stack

Open stack is an open source cloud computing platform for implementing cloud on real systems. In other word, it is not a simulator and it is installed in the real environment. The open stack uses a dashboard to access our application such computing, storage, networking and so on[7]. Let us how the open stack is working under the figure indicated us below.

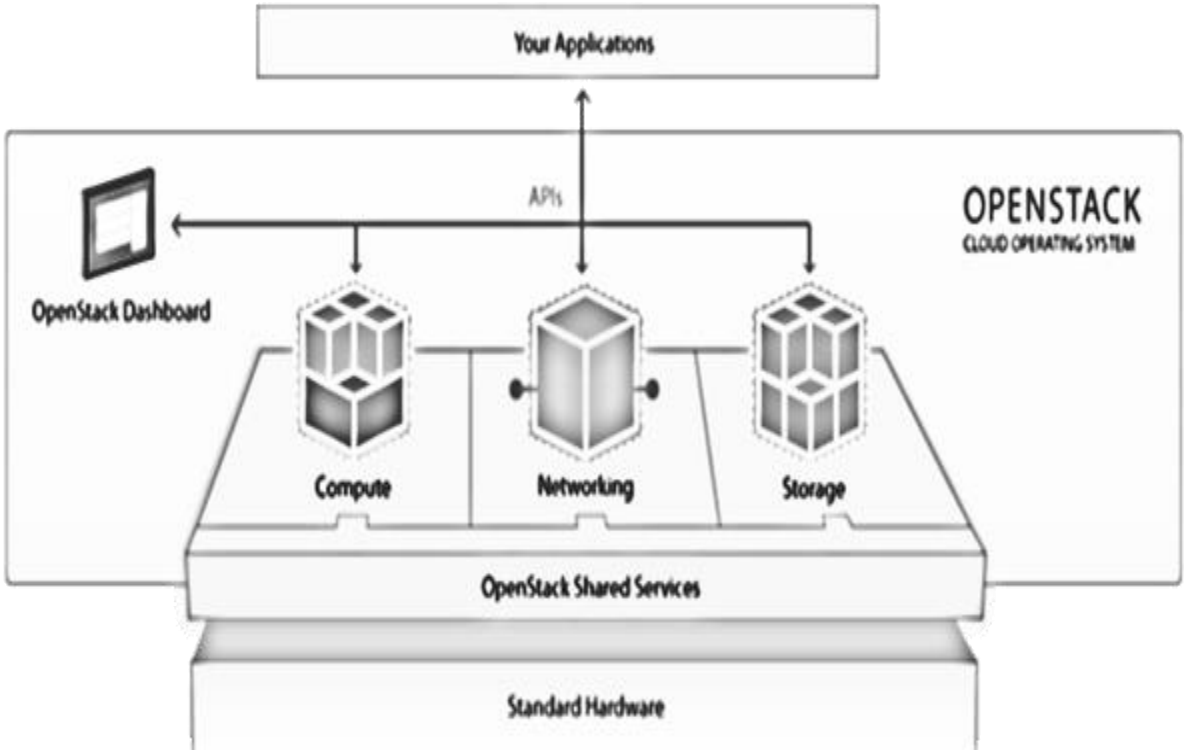

Figure 4-7: Open Stack Component[29]

[6] Opennebula.org
Open Nebula 4.8 Design and installation Guide from Open Nebula Project
[7] www.openstack.org

There are several services that can be provided by openstack and it offers Infrastructure as a Service (IaaS) and again each service offer an API (Application Programing Interface) to enable the integration among them. Let us see the following lists of some open stack service, project and their functionalities.

Table 4-5: List of Open Stack Services

Service	Project	Functionalities
Dashboard	Horizon	Allows user a self–service portal in order to open stack service[29].
Compute	Nova	Provide computing service such as scheduling, extracting of virtual machine on demand[29].
Object Storage	Swift	It stores and retrieves arbitrary unstructured data objects via RESTful, HTTP based API[29].
Identity Service	Keystone	It provides an authentication and authorization service for other Open Stack services[29].
Orchestration service	Heat	Used to integrate multiple cloud applications using a Hot template[29].

4.2 Cloud Service Provider

The selection of cloud service provider waspresented by evaluating the cloud service provider (CSP) that can best provide the different cloud Services. CSP selection was depending on the cost, service they provide, speed, storage, network, connection and the availability of constant technical provision facilities and based on these criteria's our cloud candidates wereWindows azure, Amazon clouds and Google cloud platform. In the following sub sections, there were some details about the selected CSP's candidates.

4.2.1 Microsoft cloud services

Microsoft offer various cloud service that are secure, reliable and easily accessible. These services are designed for platform, software and infrastructure. Windows Azure offers several features including computing resources, storage, database, Virtual Machines (VMs), access control, content delivery network, caching, virtual network, business intelligence, and market place.

As part of software as service concerned Microsoft provide various online service s. Microsoft online service which are subscription based, on-demand application hosted service providing end user or a consistent experience across multiple device service offering such as business productive online suit, Microsoft exchange hosted service, Microsoft dynamics CRM online and office web apps.

Microsoft windows azure is no longer remaining just provide platform but, also provide infrastructure as service as well. As part of infrastructure as a service offering is concerned Microsoft supports remote desktop and virtual machine. These two offering provide developer to direct control over underlying architecture. Microsoft is also developing solution architecture for system centre. For the cloud that helps organization to move their virtual machine on-premise solution into the cloud. By using Windows Azure, the higher educational institution and universities do not need special equipment or infrastructure; all they need is internet connection.

Windows Azure was built to help developers succeed in their application, especially for the developers who build remote data centre applications by providing different tools. Windows Azure provides a platform service which includes operating systems, a set of developer tools, and different levels on network controls to develop, host, scale, and manage developed applications on web and non-web environments [36].

4.2.2 Amazon Cloud Services

Today Amazon web services runs a global web platform serving millions of customers and managing billions of dollars' worth of commerce every year [37]. Using AWS, users can requisition compute power, storage, and other services in minutes and have the flexibility to choose the development platform or programming model that makes the most sense for the problems they're trying to solve. You pay only for what you use, with no up-front expenses or long-term commitments, making AWS a cost-effective way to deliver applications [37].

It also supports queuing, scheduling, and caching details to deal with operating systems and networking issues. Amazon Cloud provides cloud computing service such as infrastructure as service, platform as a service and software as service. The following table presents all services delivered by Amazon cloud service provider.

Table 4-6: Service Provided by AWS

NO	Service given by AWS	Functionalities
•	**Computing service**	
1.	Amazon Elastic Compute Cloud	It provides resizable compute capacity in the cloud
2.	Amazon Elastic Map Reduce	It enables businesses, researchers, data analysts, and developers to easily and cost-effectively process vast amounts of data[37].
3.	Auto Scaling	It scales Amazon EC2 capacity up or down automatically[37].
4.	Elastic Load Balancing	It can automatically distribute incoming application traffic across multiple Amazon EC2 instances[37].
•	**Networking Services**	
5.	Amazon Virtual Private Cloud	It lets provisioning a private, isolated section of the AWS cloud[37].
6.	Amazon Route 53	It is designed to give developers and businesses an extremely reliable and cost-effective way to route end users to Internet applications by translating human readable names[37].
7.	AWS Direct Connect	It makes easy to establish a dedicated network connection from user premises to AWS[37].
•	**Storage Services**	
8.	Amazon S3	It allows storing and retrieving any amount of data, at any time, from anywhere on the web[37].
9.	Amazon Glacier	It provides secure and durable storage for data archiving and backup[37].
10.	Amazon Elastic Block Store	It provides block level storage volumes for use with Amazon EC2 instances[37].
11.	AWS Storage Gateway	It supports integration between an organization's on-premises IT environment and AWS's storage infrastructure[37].
12.	AWS Import/Export	It allows in moving large amounts of data into and

		out of AWS[37].
•	**Database Service**	
13.	Amazon Relational Database Service	It makes easy to set up, operate, and scale a relational database in the cloud[37].
14.	Amazon Dynamo DB	It provides fast and predictable performance with seamless scalability[37].
15.	Amazon Elastic Cache	It makes easy to deploy, operate, and scale an in-memory cache in the cloud[37].
16.	Amazon Redshift	It is fast and cost-effective to efficiently analyze all your data using your existing tools[37].
•	**Deployment & Management**	
17.	AWS Identity and Access Management	It allows to securely controlling access to AWS services and resources for your users[37].
18.	Amazon Cloud Watch	It provides monitoring for AWS cloud resources and the applications customers run on AWS[37].
19.	AWS Data Pipeline	It helps you reliably process and move data between different AWS compute and storage services[37].
20.	AWS Ops Works	It used for managing applications of any scale
•	**Application Services**	
21.	Amazon Simple Queue Service	It offers a reliable, highly scalable, hosted queue for storing messages[37].
22.	Amazon Simple Notification Service	It makes easy to set up, operate, and send notifications from the cloud[37].
23.	Amazon Simple Workflow Service	It used for building scalable, resilient applications
24.	Amazon Simple Email Service	It eliminates the complexity & expense of building an in-house email solution or licensing, installing, and operating a third-party email service[37].
25.	Amazon Cloud Search	It allows customers to easily integrate fast and highly scalable search functionality into their

		applications[37].
26.	Amazon Elastic Transcoder	It is used convert video files from their source format into versions that will playback on devices like Smartphone's, tablets and PCs[37].

4.2.3 Google Cloud Platform

Google Cloud Platform is a package consists of various cloud computing services that are presented by Google. These services include computing, web application development and a variety storage solution. The Google Cloud Platform offer cloud computing service such as infrastructure as service, platform as a service, software as service and other as a service. Let discuss the service given by Google Cloud Platform in this section.

Google Compute Engine: - is one of the services given by Google cloud in order to provide infrastructure as a service to offer a cloud user a virtual machine. Google Compute Engine can be managed through a RESTful API, command line interface or web console. Google Compute Engine manages and administrates the virtual machine, DNS server and load balancing through application programming interfaces[8].

Google App Engine: - it is a platform allows the developer to build web application that run on the app engine using software development kit. It offers platform as a service to the cloud users. Google App Engine involves application that could be written in Java, Ruby, PHP or Python as well as store data in Google BigTable and using Google query language. Google App Engine reduces administration and developmental tasks to make system easy to use, easy to scale[9].

Google Storage Cloud: - is a Google cloud platform designed to provide storage to store large volume of data, unstructured data set as well. It provides storage such as Cloud data store for NoSQL non-relational storage, Cloud SQL for MySQL fully-relational storage and Google's native Cloud Bigtable database[10].

[8]http://searchaws.techtarget.com/definition/Google-Compute-Engine

[9]http://searchaws.techtarget.com/definition/Google-App-Engine

[10]http://searchcloudstorage.techtarget.com/definition/Google-Cloud-Storage

Summary of the comparisons

Let us compare and contrast the above selected cloud providers to summarize their feature based on[11]. The following table shows the summary of the comparison.

Table 4-7: Summary of the Comparisons

Feature	Windows Azure	Amazon Web Service	Google Cloud Platform
I/O Speed	Third place	Second place	Frist place
Load Balancer	Traffic Management Combined Solution	Elastic Load balancer (internal) and Auto-scale (external)	Combined Solution
Block Storage	1TB	1TB	Up to 10 TB
Global Network	Global Datacentre Infrastructure	Wide Regional Offering	Narrow Region and Faster Per Connection
Connection	Open Internet	Open Internet	Regional Fibre Network
Pricing	Per Minute-Rounded Up Commitment (pre-paid or monthly)	Per Hour- Rounded Up	Per Minute – Rounded up (minimum 10 minute)
Models	On Demand, Short term Commitment (pre-paid or monthly)	On Demand, Reserved, Spot	On Demand, Sustained-Use

[11] https://www.quora.com/How-do-AWS-Microsoft-Azure-and-Google-Cloud-compare-to-one-another

5 Chapter Five: Proposed Federated Cloud Based E-Learning Framework for Ethiopian Universities

In this chapter the researcher need to focus on the proposed solution which was particularly on the allocation of virtual machine in cloud federation for educational e-learning in the universities. In generally,the objective of this chapter was to investigate on the issue of such as knowing the detail of federated cloud, modeling the proposed solution and allocation of virtual machine in the cloud federation.

5.1 Building up Framework for Federated Cloud Based E-Learning in Universities

This research proposed a model of federated cloud computing infrastructure resource allocation for HEIs. The proposed federated cloud computing model for higher education institutions contains five layers.We have developed this framework based on centralized cloud federation approach which was proposed by Calcavecchia [25] and discussed in the literature review of chapter two.

The following figure shows the framework of our proposed solution.

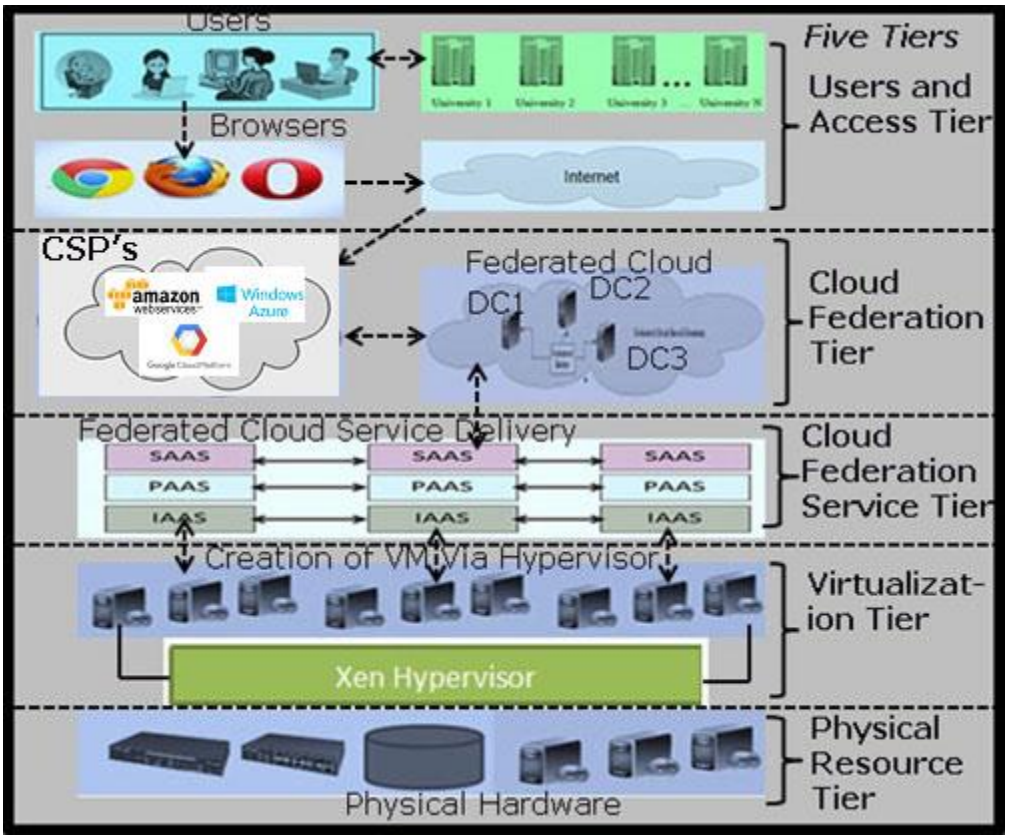

Figure 5-1: Proposed Frameworks for Federated Cloud Based E-Learning

The proposed five tiers in our framework are described as follows:-

5.1.1 User and Access Tier

This layer is containing different type user such as lecturer, administrators, staff, and students as well as represent other community member of the university. Under this tier, we had a number of universities that were going to use a common resource through cloud federation.

In this layer, the user of system can make request through the internet to federated cloud broker which submit the user request to the cloud federation and allocate the required resources. The requests that could be made by the userswere virtual machine and the virtual machines were allocated to the user via federated cloud broker.

The user interacts with the federated cloud e-learning systems through their end device such as laptops, smartphone, and tablet and so on to use any kind of cloud service via established internet connection.

In addition, the user should have a web browser in order to access a particular application that was located on the cloud through an internet connection. The service catalog should be available with complete information about the layer that contain the service and who can use the particular resources. In this tier, there was a service repository thatwas composed of

several services such e- learning software, hardware, courses content, and student information and so on.

5.1.2 Cloud Federation Tier

In this layer, we created a centralized federated cloud based e-learning datacentre that contain federated cloud broker which submits the user requirement and provides the service to cloud user from cloud service provider as well as control and create resource in the several datacentres. We know that, each university has at least one data centre so, several university have a various number of data centre.In this layer coordination, creation of virtual machine in the datacentre and allocation virtual machine to host among threedatacentre via federated cloud broker was established. The federated cloud e-learning datacentre was placed at provider side which provide the infrastructure resource and service. In this research the selected cloud provider candidates were amazon web service, Microsoft azure and Google cloud platform.

Cloud Federation for Several Universities

We know that, different cloud service provider can expand the functionality of cloud computing to the several sector such as health institution, educational institution, business sector and so on, by offering all the essential resource and services based on their demands.
The federated cloud model was proposed to serve the current IT infrastructure for educational institutions services. Harnessing the federated cloud computing technology for delivering different services such as e-learning systems service such as class room management systems, e-learning content management systems, deployment e-learning software and hardware, researching and similar services give more flexibilities and dynamic resource utilization which solves the scalability issues.

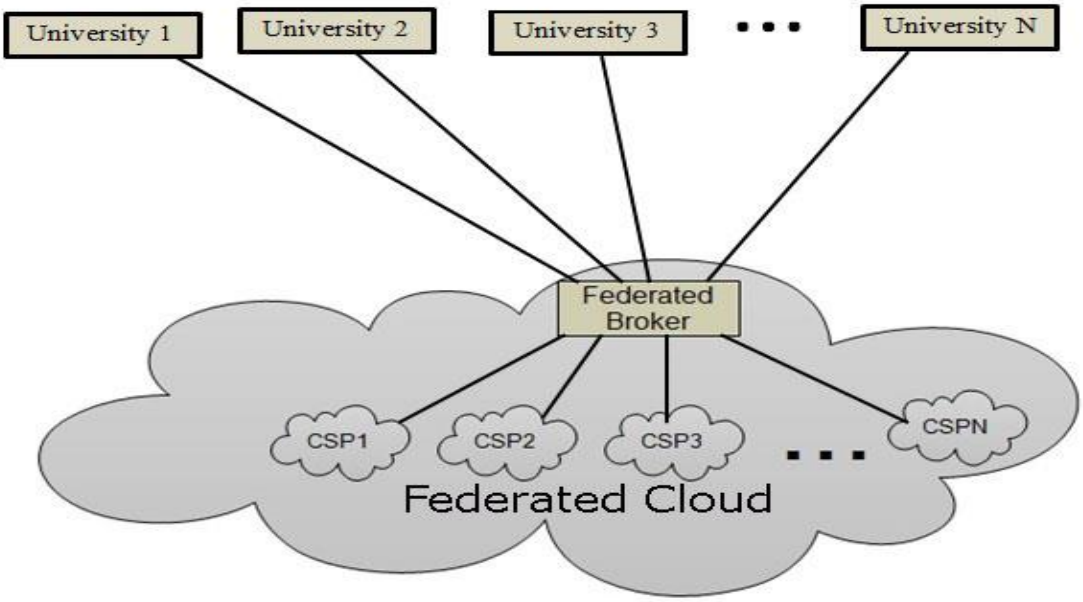

Figure 5-2: Framework for Federated Cloud of Various Universities

Cloud Federation for Three Universities

We had assumed that there were different data centre at different universities and we had created three e-learning data centre which were located across different regions. Here, as the figure shown below we had created data centre at Addis Ababa University, Adama Science and Technology University and other in Hawasa University. In order to interconnect all of these three datacentre through a centralized datacentre broker, in our case, it is via a federated datacentre broker which is going to manage, coordinate, allocate and collaborate educational resources.

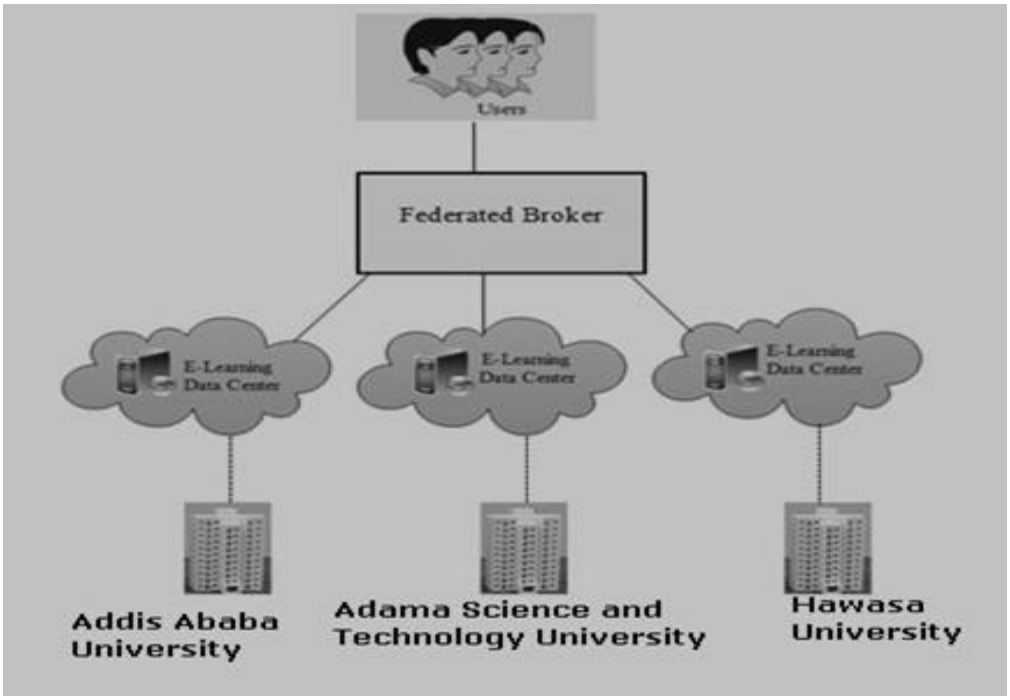

Figure 5-3: Cloud Federation for Three Universities

5.1.3 Cloud Federation Service Delivery Tier

The cloud service delivery such as Infrastructure as a service, platform as a service and software as services were must be anticipated for developing of federated cloud e-learning systems. When we came to our implementation, it was all about managing and allocation of virtual machine in federated datacentre which was from the perspective of infrastructure as service in the cloud service delivery model.

No single cloud computing services model is expected to meet all the technology requirements for e-learning systems. Instead, educational institutions should develop and maintain all major service cloud computing service such IaaS, PaaS, SaaS together.

Higher education institutions can improve the teaching, learning and research environment by utilizing SaaS to enhance the environment by adding more interactive and valuable tools, PaaS to improve software application development environment by using standard and scientific methods, IaaS to overcome the allocation learning infrastructure resources. Let have discuss all the views cloud service deliveries.

- From the Infrastructure as a service point of view:
- Virtual machine management for the learning system and the learners.
- Balancing the load across several learning systems.
- Scaling and allocation of virtual machines to hosts.
- Storage for learning applications.

➢ From the platform as a service point of view:

- Managing learning management software.
- Running and installation programming language and IDE.
- Making interoperability among different management software across learner.
- Creating learning management system software.

➢ From the software as services point of view:

- The registration of application management.
- Managing service such as learning contents to the users.
- User account management for authorization and authentication.
- Course content management.
- Managing session used by the learner of application.

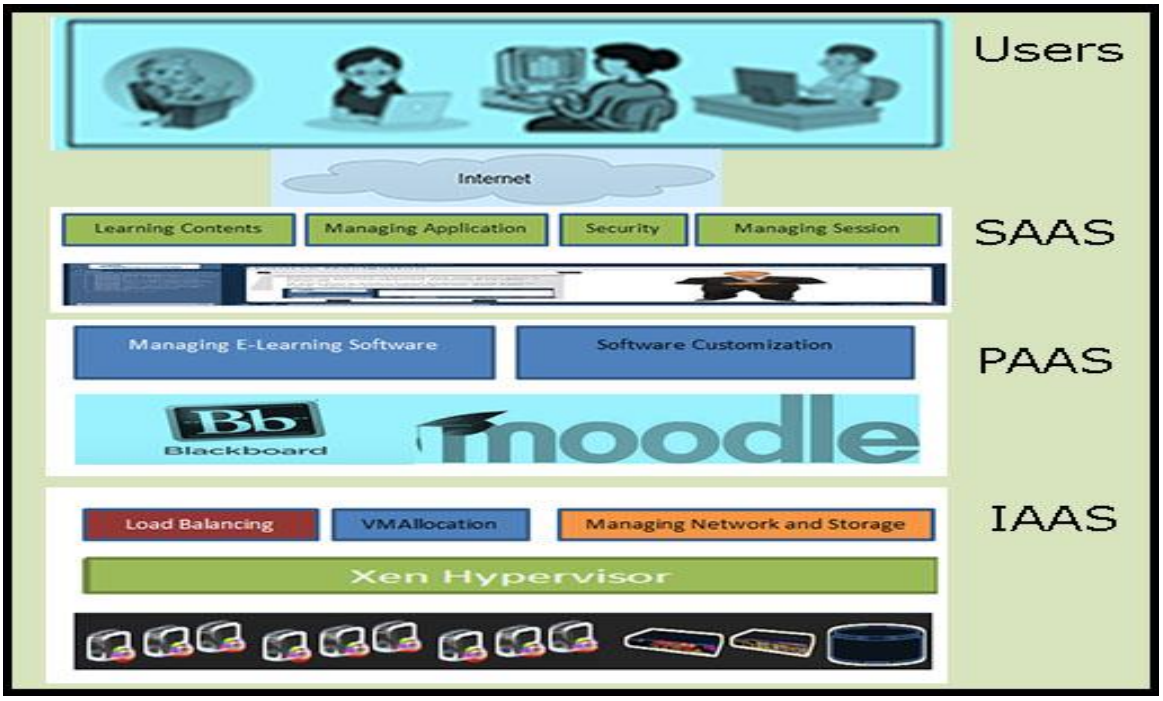

Figure 5-4: Framework for Federated Cloud E-Learning Service Delivery Model

5.1.4 Virtualizations Tier

Virtualization is an "abstraction layer" that means the operating system is no longer depend on the physical hardware it run on. Virtualization can be applied with many systems with in information technology (IT). These can be hardware, software or combination. The common systems where virtualization can be applied are servers, storage, networking, application etc. The operating system are abstracted from the hardware in other word, the operating system is not directly installed on that hardware. Instead there is a layer in between the server and operating that normally installed is called Hypervisor. This hypervisor allows us to run

multiple virtual machines or guest computer each with their own operating system on the same physical server hardware. Let have a look at, how an e-learning server was going to be virtualized. Frist of all, an e-learning server was a standalone server so; to virtualize this machine we had to use hypervisor which separate software such as application, operating systems from the hardware machine. In this scenario, the combination of application and operating system was termed as virtual machine (VM). The hardware simply provides a computing resource to the virtual machine such as CPU, storage, memory and network access. The need of virtualization was because of the standalone system usually run under <10 % utilization. In other word, the resources required were massively bigger than as single server and economically traditional server were wasteful of resources.

In this layer, an e-learning server were virtualized using a software Xen hypervisor in order to create virtual server machine. With an e-learning server virtualization, we can replace the physical e-learning server with various virtual machines thus bring many benefits in terms of cost, energy saving for the organization. We had again a bigger advantage, if we apply virtualization to different e-learning server datacenter instead of single datacenter. In our proposed solution we had created three distinct datacenter so that, we can allocate virtual machine from one datacenter to another by using scheduling algorithm. Hypervisor was used to create virtualization layer that makes server virtualization was possible. For virtualization purpose, we were using a Xen Hypervisor which was classified under type 1 hypervisor. Hypervisor can be developed by different vendors such as VMware, Citrix, and Microsoft etc.

5.1.5 Physical Resource Tier

It is the physical layer in several resource infrastructures which going to be virtualized is existed. The following were some possible physical resource found in layer. These were listed as follows:-

- Server
- Storage
- Network
- Firewall and so on

5.2 Modeling Resource Allocation in the Federated Cloud

We know that, virtualization acts as an engine in the cloud computing in order to create a virtual infrastructure resource such as CPU, Memory, and Storage in the form of virtual

machine. We were describing in our model about cloud e-learning infrastructure resource allocation such as mapping the virtual machine to various host that was created under several datacenter. This studies focus on the allocation virtual machine to the cloud user based on their demand from federated cloud infrastructure. We can establish infrastructure as service in order to launch the e-learning educational resource over the cloud federation which allows the interconnection of several geographical dispersed cloud e-learning datacenters.

To allocate the resource such as virtual machine, application to the cloud user in the cloud federation under which several cloud provider were interconnected together, resource were allocated through a centralized broker called federated broker.Federated broker allows allocating, coordinating, controlling and managing cloud resource. In the figure shown below we had several datacenter that were located in various universities, when request comes from the cloud user the resource were created by the federated broker and the request wereagain executed based on scheduling algorithm and the requested resource were submitted to the end users. Let us see the data flow diagram that illustrates how the request was going to be processed in the federated cloud.

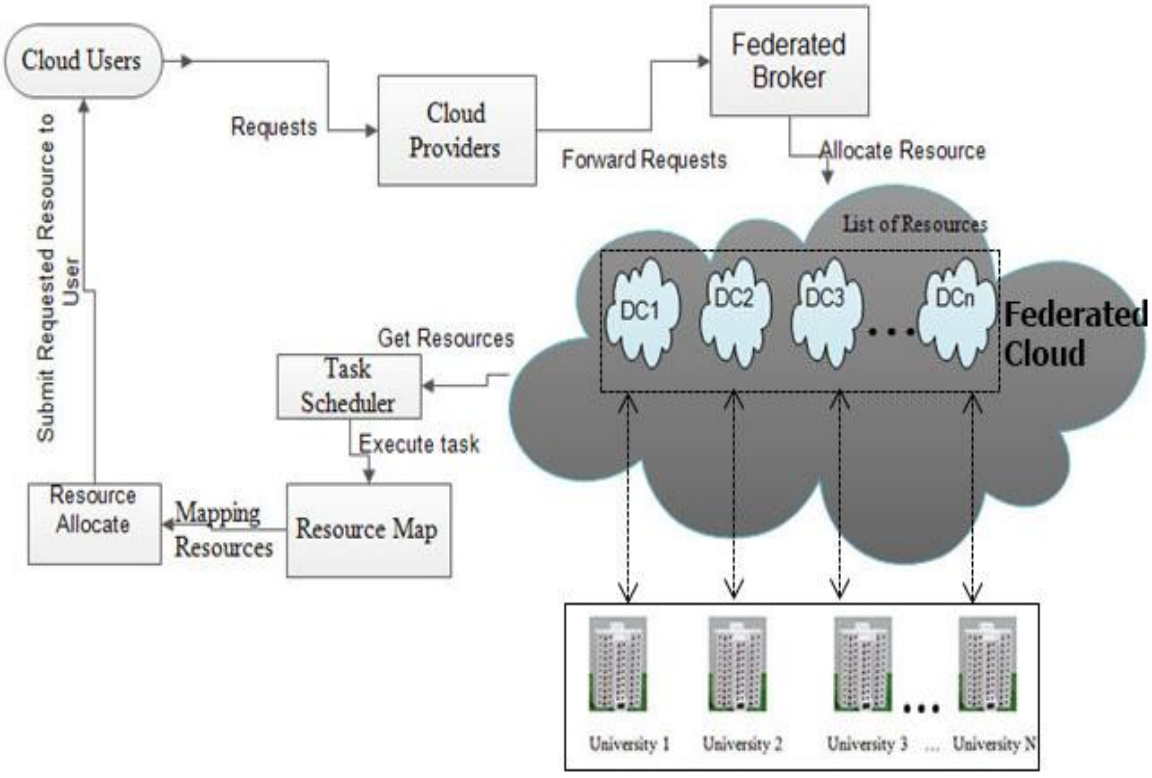

Figure 5-5: Data Flow Diagram of Proposed Federated Cloud Resource Allocation

To do so first of all, the request were created and submitted to the federated broker to ask the resource they need in the datacenter. Then, the federated broker was going to checks weather the datacenter was available or not. If it was available then, it was going to create virtual

machine inside this datacenter otherwise; it returns that there was no requested datacenter in the federated datacenter. After creating virtual machine in the federated datacenter, it was going tobe scheduled using scheduling algorithm. We were using a round robin algorithm that allows to execute user request in the sequentially manner with in some fixed amount of time. Then after, the virtual machines were scheduled in the round robin fashion in order to map the virtual machine to hosts. Finally, the virtual machines were submitted to the cloud users through federated broker. The following figure shows the flowchart of resource or virtual machine allocation in cloud federation.

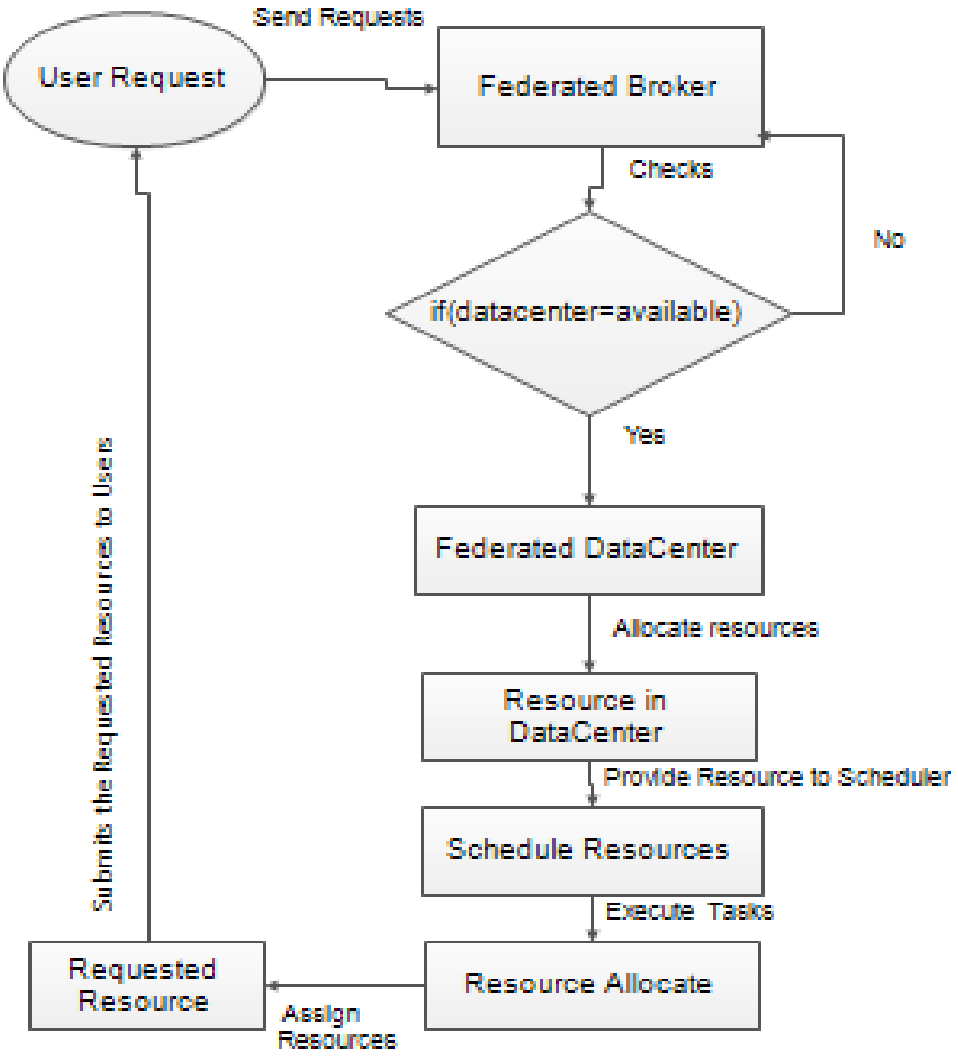

Figure 5-6: Flow Chart of Proposed Federated Cloud Resource Allocation

Federated broker was used in order to solve the problem of resource allocation from several geographical dispersed datacentre. Federated broker acts as a central component of cloud federation. It was responsible for allocating resource to several datacentre that were located in various regions.

5.3 Virtual Machine Allocation Scheduling Policies and Algorithm

Basically, whenever we run any application on any system, we need the best performance so that, for efficient performance of any system, there was also a need of effective scheduling. Scheduling is an allocation of various tasks of a given resources in the given time. That was how we were going to look at various tasks to several kinds of resources. There were different limitation given by both cloud user and cloud provider. A limitation given by cloud user are such as a given deadline on a given purchase or they want to have their tasks finished in the given timeand they want spend alimited amount of budget on the tasks. Likewise, the limitations given by cloud provider are they want to maximize their resources and they want to increase their income.

There are two scheduling policies

I. **Time Shared Policy**: - The virtual machine can be allocated simultaneously or concurrently. They share virtual machine parallel with some time slice. Each task gets virtual machine for running the requests in a given period of time. After some period of time virtual machine are taken away from that particular task and assigned to another tasks. The VM scheduler time shared class is used in the cloudsim toolkit. The cloud computing scheduling resource allocation algorithm used for time sharing is round robin algorithm. Round robin algorithm is supporting time sharing policies which allows preemption. In order to implement virtual machine allocation in federated cloud of our proposed solution, we had used timesharing policies by implementing round robin algorithm. The reason we had choosing this kind scheduling policies was that with limited amount of resource it can execute a numerous of requests at one time. However, in the space shared policies requires a lot of resources for the execution of user requests.

II. **Space Shared Policy**:- This policy could be take place if we have suppose one processor in the host and we want to create two virtual machine, in the space shared one processor is first used by one virtual machine then, after finishing its tasks gives the resource to the next virtual machine uses sequentially one by one. When we compare time shared policy with space shared policy, in case of space shared policy there was no sharing of virtual machine among tasks and the resource were assigned to cloudlet or task step by step in such a way that, after one task was being executed then, the next task was going to be executed. The cloud computing scheduling resource allocation algorithm used for space

shared policy is first come first served algorithm. By default cloudsim support this kind algorithm.

6 Chapter Six: Implementation of the Proposed System Using Cloudsim, Analysis and Validation of Results

In this chapter we were going to discuss on analysis, implementation as well as validation of result of our studies. The implementation and output of our proposed system was done through a cloudsim toolkit. The result of our implementation was analysed and validated in this section.

6.1 Implementation and Analysis of Results

The main objective of this research was to allocate virtual machine in the federated cloud in order to solve the limitation of collaboration or integration among different higher educational institution and maximize and increase the infrastructure resources for various public universities. The federated cloud based e-learning model would enable service delivery much and more effective and efficient in particularly, on the resource allocation and utilization of resource. Therefore, the federated cloud based e-learning system had betterperformance and response time than the existing web based e-learning system or cloud based e-learning system which was not federated.

Experimentation with Cloudsim

For the purpose of implementation, testing and evaluation of performance, we had used open source cloud simulation tool which is called cloudsim. In our experiment, we had created three datacenter and adding a host in each datacenter where each host had 8GB of Memory and 1 TB of storage.

To implement virtual machine allocation in federated cloud, we had created three separated datacenter and three different hosts. Each virtual machine was assigned to the datacenter by the federated data center broker. Again round robin algorithm was used to schedule for time shared policy with a given virtual machine in the datacenter in order to assign resource to the

existing host and submit the virtual machine to the cloudlet.Let us look at the different data center characteristics used in the experiment from the following table.

Table 6-1: Data Centre Characteristics

Characteristics	Datacenters in three Universities		
	Addis Ababa	Adama Science and Technology	Hawasa
Operating System	Linux	Linux	Linux
Architecture	x86	x86	x86
Hypervisor	Xen	Xen	Xen
Time Zone	10.0	10.0	10.0
Cost Per Memory	0.05	0.05	0.05
Cost of Processing	3.0	3.0	3.0
Cost of Bandwidth	0.1	0.1	0.1
Cost per Storage	0.1	0.1	0.1

The characteristic that each host list has in the datacenters is described in the following table.

Table 6-2: Host List Characteristics

Characteristics	Host Lists		
	Host1	Host2	Host3
Processing Element	QuadCoreMachine	DualCoreMachine	DualCoreMachine
MIPS	1000	1000	1000
RAM	8GB	8GB	8GB
Storage	1TB	1TB	1TB
Bandwidth	10000	10000	10000

I. Scenario One:- Creation of virtual machine in federated data center

From the above the section,we hadcreated three datacenter such Datacenter1, Datacenter2 and Datacenter3 as well as three hosts. For purpose this experiments, we had only created ten virtual machines in the datacenter. The first experiment was to assign virtual machine to these three datacenter. By doing so, the result weregenerated via simulation tools indicated as follows.

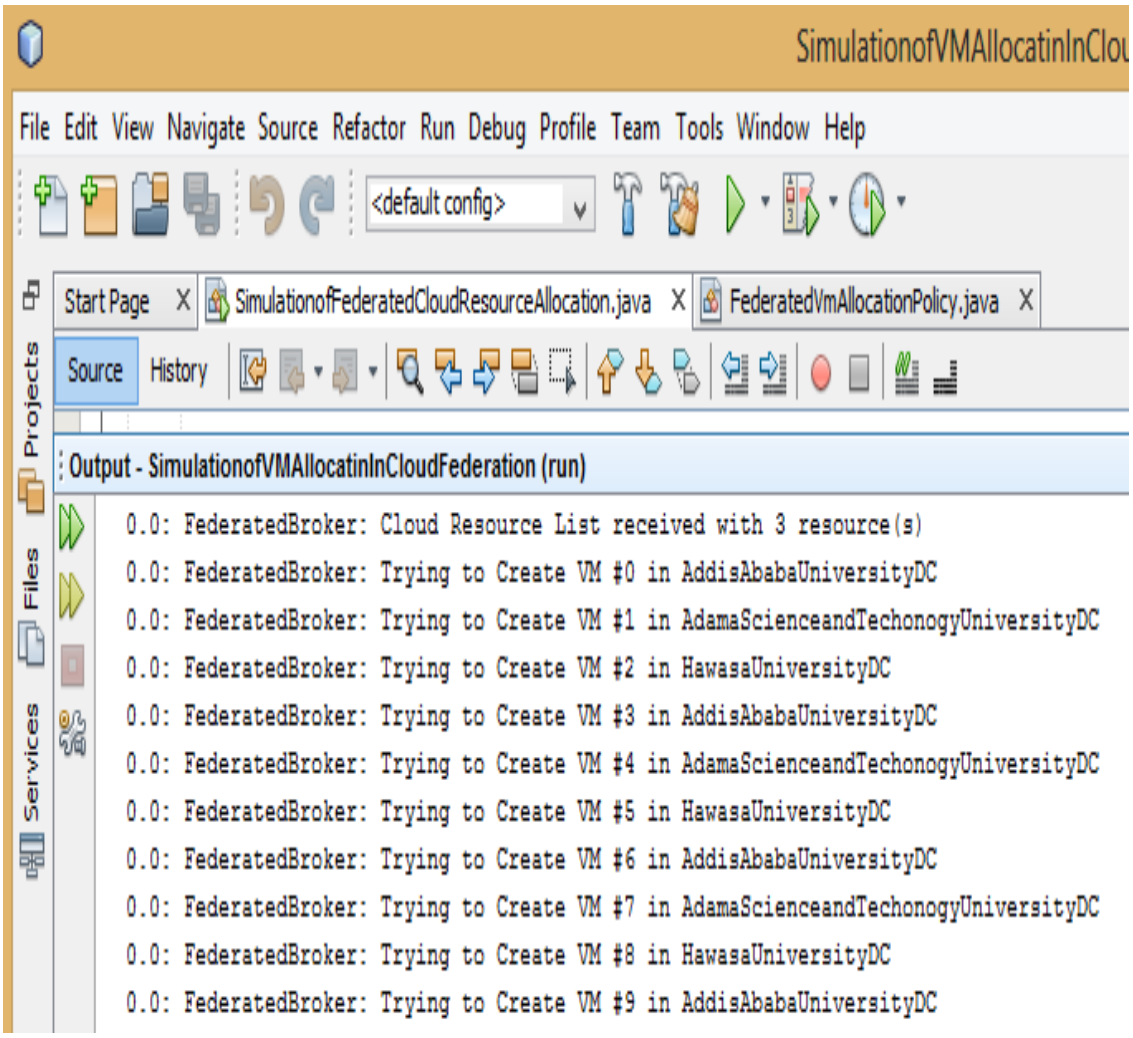

Figure 6-1: The Output for creation virtual machine in the data centre

II. Scenario Two:- Allocation of virtual machine to hosts

In this experiment, we were using round robin VM allocation algorithm in order to allocate virtual machine to the host. In our experiment, we mapping those virtual machine to three hosts and what the algorithm does was to extend the virtual machine allocation policy which was a time shared policy and create a host list in order to assign virtual machine in a sequentially manner. The output of this can be shown as the following snapshot screen.

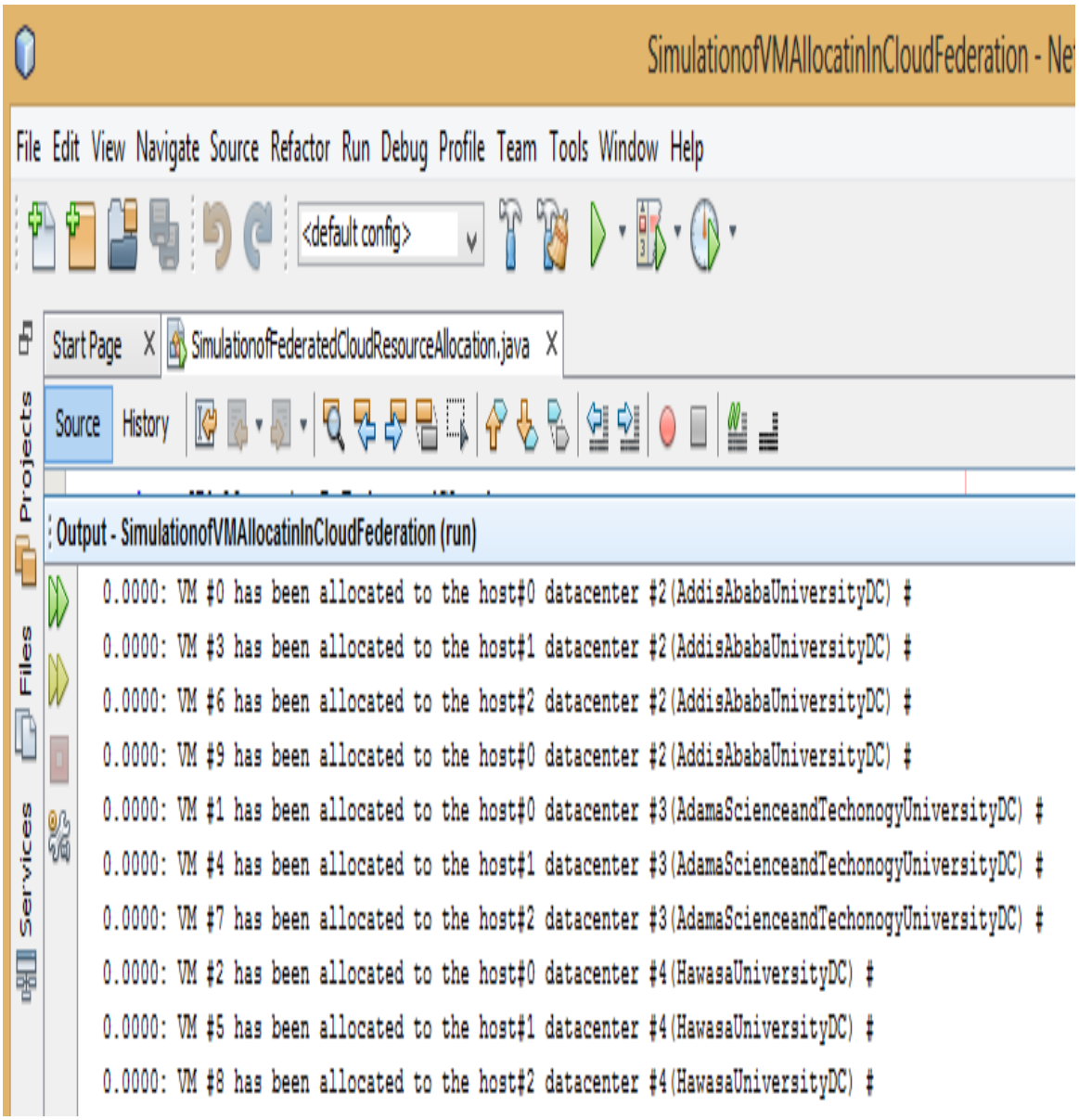

Figure 6-2: The Output for allocating virtual machine to hosts

III. Scenario Three :- Submitting Virtual Machine to the Cloudlets

Based on the scheduling algorithm which assigns each virtual machine to the different host and the federated broker takes it task to submit the virtual machine to the cloudlet. The cloudlet is the tasks or request comes from user. For the purpose of this experiment, we had created only twenty cloudlets and ten virtual machine so, these number virtual machine are submitted to the cloudlet in the round robin fashion. The following was the snapshot that clearly indicates this scenario.

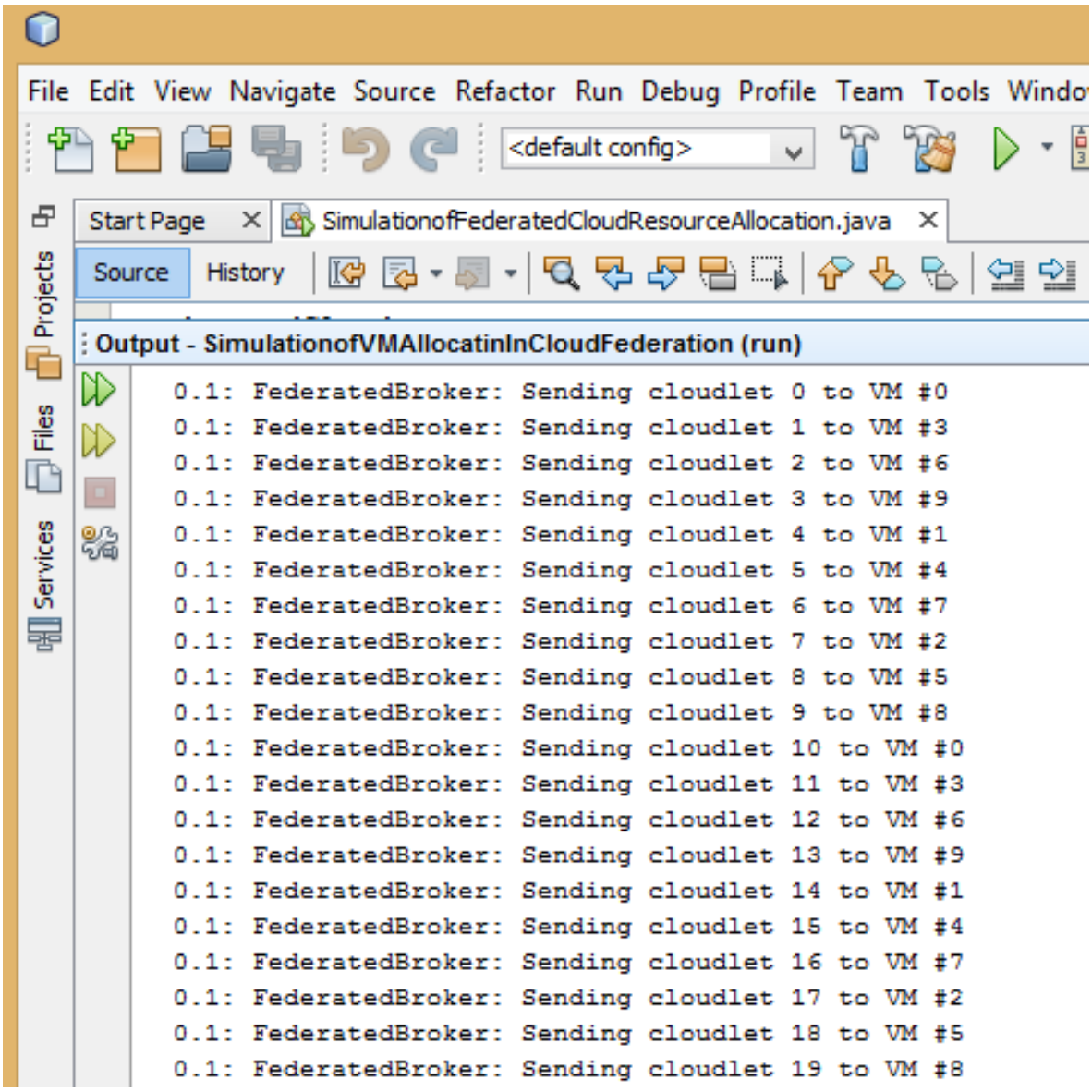

Figure 6-3: The Output for submitting virtual machine to cloudlet

IV. Scenariofour: The output for proposed federated cloud

The overall result generated by the above experiment with cloudsim simulator to show the summary and status of virtual machine allocation in federated cloud. Here we can see, the start time and end time were the time taken for the users to request virtual machines and accepts their responses. Therefore, from the output there was a time gap between start time and finished time and itwas an execution time taken by the scheduling algorithm in cloudsim. The result can be indicated as screen snapshot as follows.

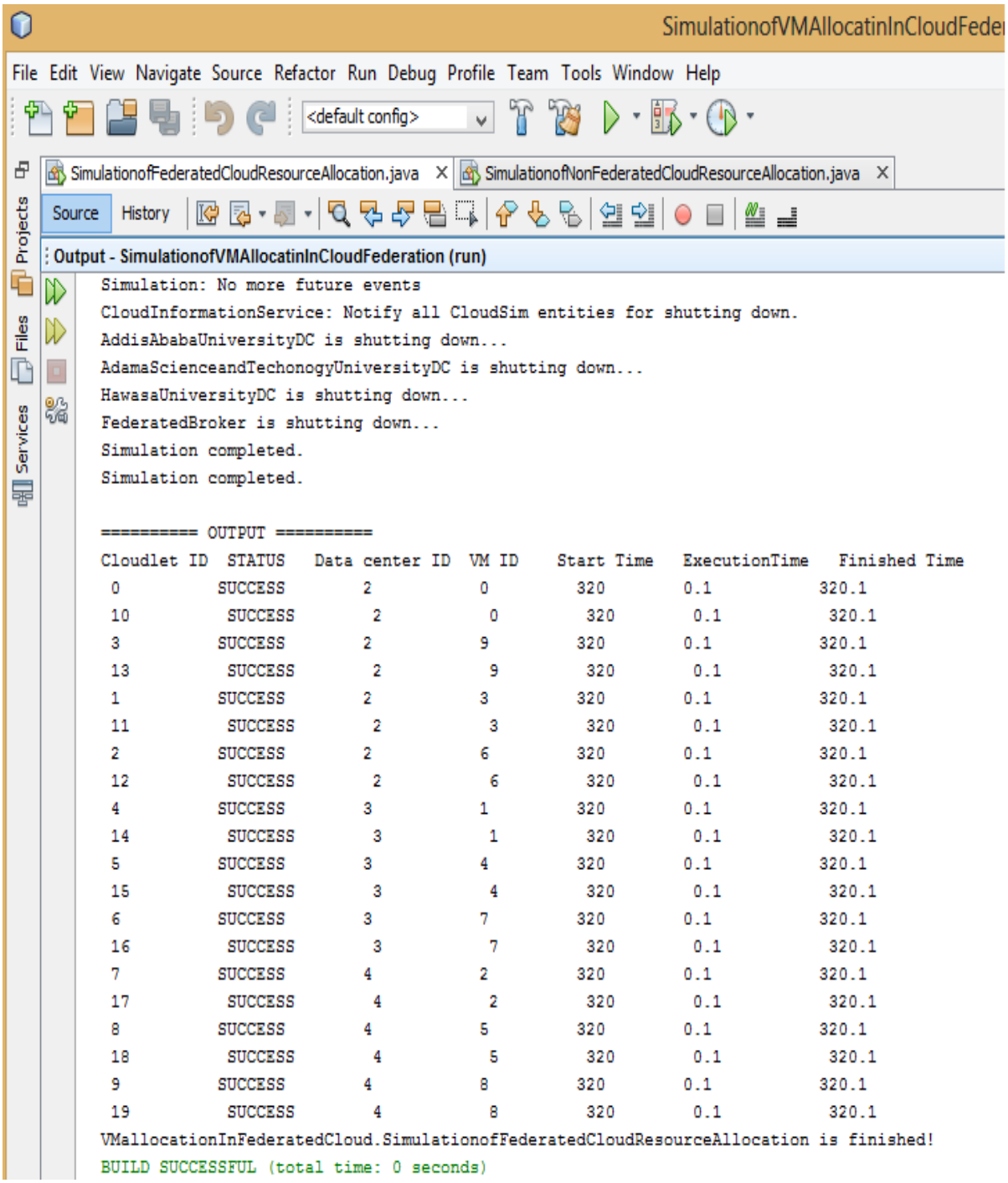

Figure 6-4: The Output VM allocation for federated cloud

From the above result, we examined the three e-learning datacentre that are found in different geographical region are connected through federated broker.The virtual machine are successfully created at those different cloud datacentre.The mapping of virtual machine with a set of host list are accomplished.The submission of virtual machine resource to cloudlet are accomplished and every cloudlet are assigned to the existed number of virtual machine concurrently.Finally, depending on the summarised result generated by simulation, we have evaluated that our system have better execution time, integrated and virtual machine resource which provided by the cloud service provider are successfully allocated cloud user.

6.2 Validation of the Results

Depending on the results, we hadobtained from our proposed solution; we can show and compare how our proposed system was better over legacy system in order to indicate the validation of the results.To show the improvement of our proposed federated cloud system framework and prototype over non-federated system, we can correlate our result obtained with the existing problems. The following were some major point to indicate the validity of our results.

- In non-federated cloud consistinga number of datacentre, the creation and allocation of virtual machine were failed due to lack infrastructure resources and the resources were not integrated. .
- Compared to federated cloud, a non-federated cloud requires huge amount resource such as bandwidth, processing, other hardware or software infrastructure when, more requests were coming.
- There were equal distribution of virtual machine for a number of datacentre in case of federated cloud system however, in non-federated cloud there were no equal distribution of virtual machines.
- The execution time in the federated cloud wasfaster than non-federated cloud.
- The execution time in our proposed federated cloud was double than a non-federated cloud as it was displayed on our result. This signifies the quality of service such as performance, response time was much better than non-federated cloud.
- The following figure shows the output from non-federated cloud which helps us to present the above correlation between the proposed system and the legacy system.

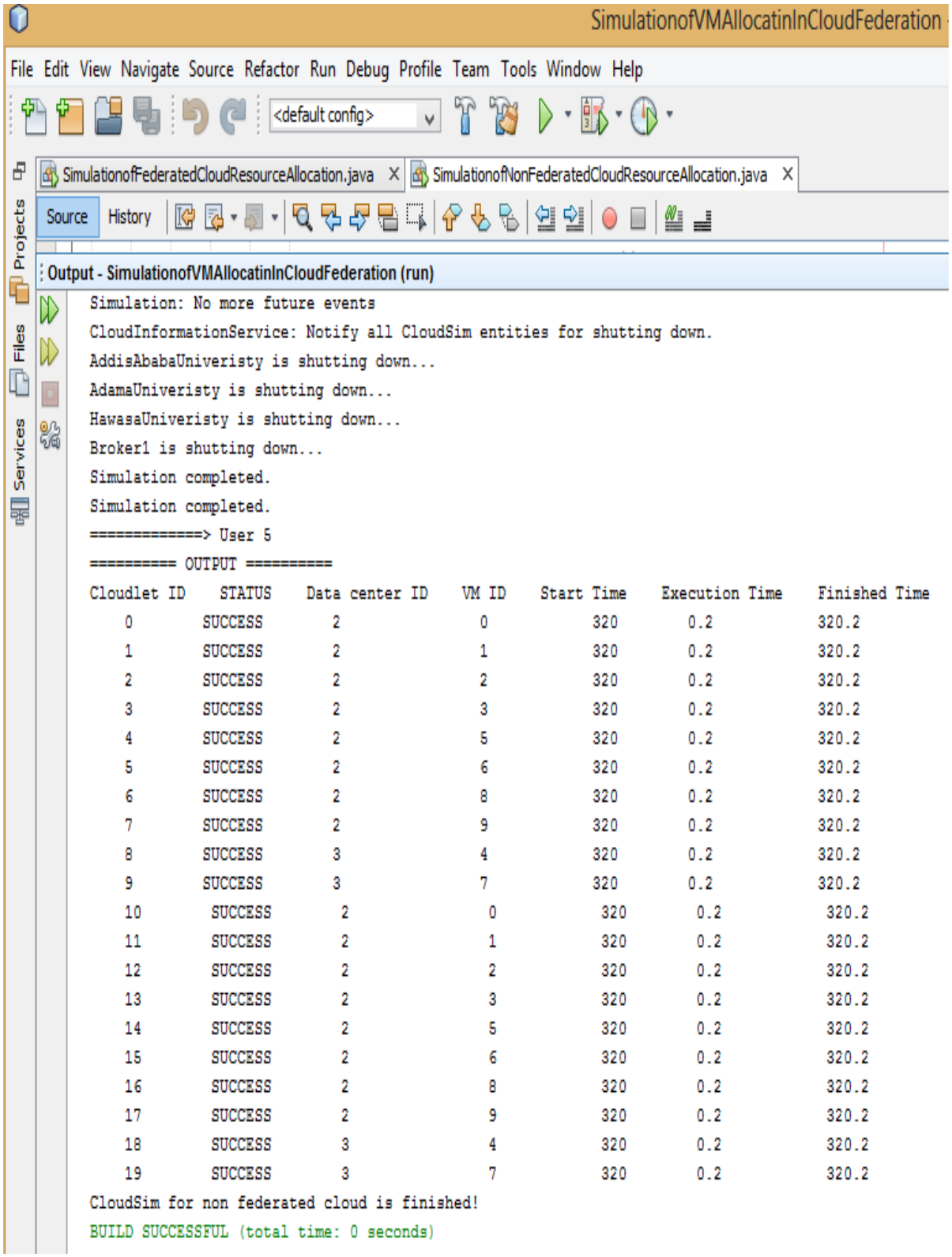

Figure 6-5: The Output for non-federated cloud

7 Chapter Seven:Conclusions and Recommendations

7.1 Conclusions

We know that, cloud computing works on the principle features of virtualization and sharing of resources across the networks. Every organization needs an elastic, cost-effective and scalable technology in order to better optimize and utilize their resources. This study was identified and analyzed the area of e-learning system in higher educational institutions. The transformation of legacy e-learning system into the cloud computing form cloud e-learning which provide cost-effective solution to the educational sector. The study was started by reviewing related literature in the area of cloud based e-learning system and identifies that many researcher were proposed it to different sector. In this we compare and contrast between the existing e-learning system and cloud e-learning system. We also further discuss on the approach, benefit and challenge that the web based e-learning, cloud based e-learning and federated cloud had in the higher educational institutions. Finally, our next approach which was going to solve the limitation of both traditional web based e-learning system and cloud based e-learning system could be building up cloud federation which was very important and a new a concept to establish unlimited resource in cloud computing paradigms. In the evolution of computing technology a cloud federation is new paradigm of cloud computing. By applying a federated cloud based e-learning to the higher educational institution, it allows us to combine together different kind of resources found in different universities under a single large cloud by providing an efficient resource allocation and increasing resource availability among Ethiopian higher educational institutions. This kind of cloud comprises of a variety cloud service providers which provide an e-learning service to each universities. Implementing cloud federation into the higher educational institution would bring unlimited access of educational resource. In this paper, we were trying to build up federated cloud based e-learning, to do so, we were following a centralized cloud federation approach which allows creating a single broker to interact with several cloud data center in order to allocate resource and interconnect all of them together.

7.2 Recommendations and Future Works

Cloud federation would be better incorporated to the education environment because of carrying out huge investments and sharing of education resource across several institutions. Most likely, Cloud federation would be more reliable and carry fewer risks for clients in the future. Until the innovation of better and new IT infrastructure delivery model, Cloud federation continues to offer better performance with lower costs to IT world.

In our work we recommended that, firstly of all, the implementation and testing of the proposed cloud federation model with intensive feedbacks from users and experts, so as the proposed model to be modified before implementing it immediately at institutional level. Then, measuring the usefulness and productivity of the federated cloud model as well as comparing and contrasting with currentexisting model, evaluating the cost effectiveness of proposed models with the existing legacy models should be carried out.

In this research, we were using a simulation environment in order to implement and run the proposed cloud federation, in future we suggest that real cloud platform such open nebula open stack or cloud stack have to be deployed to implement federated cloud. In this study using cloud federation e-learning as infrastructure as service however, in the future we expect a model cloud federation e-learning platform as a service, software as service and other as a service.

It wasvery important to apply cloud federation in order to interconnect various educational resource such e-learning service, educational research,ICT infrastructures and so on. In the future, we hope that all Ethiopian higher educational institutions connected together through cloud federation and again interconnected to various African universities as well as to several world universities in order to exchange educational infrastructures resources, research and best technologically transformation across several higher education institutions. Therefore, we recommended that cloud federation can be used not only to interconnect the national higher education e-learning datacentre but also, it can interconnect international higher educational institution as well so that, they can share and allocate educational resource in the worldwide.If there are any kind of doubts, questions and comments in this study can be considered as opportunities for future works.

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Appendices

Appendix -I: Interview and Questionnaire

I. Open Ended Interview Questions

1. Is there an e-learning system deployed in your organization? If no, why it is not deployed yet?
2. What are the challenges of an existing e-learning system in your institutions?
3. To what extend the accessing of e-learning resources is for lecture preparation, to write articles, to upgrade and improve subject knowledge, for research purpose (research project), to create academic communication from other universities?
4. Does your university have institutional repository data base containing teaching materials, peer-reviewed journals, conference proceedings, reports, thesis and dissertation?
5. How much your institution spends for resources buying like hardware and software in month/year?
6. What do you think about the future E-learning system deployment, do you think it can solve the current challenge of educational system?
7. What kind of computing you can suggest in solving the current challenge of E-learning system?
8. Do you think cloud computing helps to reduce the expenses that go to buy hardware, servers, software or maintenance?
9. Which cloud deployment model (public, private, hybrid, community, inter cloud or virtual private cloud) is better for higher education institutions?
10. Do you think the implementation of federated cloud computing technology at the higher education helps to improve the resource utilization of universities services?
11. Do you think cloud federation help students to communicate with each other higher education institution, save and share data and allows collaboration among others several institutions?

II. Closed Ended Questionnaire and Response Evaluation:

Dear respondents this section is about the challenge of current e-learning system and suggested computing solutions. Please indicate the extent to which you agree or disagree with each of the following statements regarding challenge of e-learning system in your institution and suggested computing solutions. Tick (√) your choice either strongly Agree, Agree, Undecided, Disagree or Strongly Disagree.

	Questionaries'	Agreement Level					
Part 1	**The current challenge of an existing e-learning systems in Higher Education institutions**	**Number of Respon-dents**	**Strongly Agree**	**Agree**	**Un-decided**	**Dis-agree**	**Strongly Disagree**
1	Is there a low speed internet connection in your institutions?	44	30%	41%	5%	16%	9%
2	Is there a limited collaboration among students to communicate, save and share data with each other and collaboration with other higher education institution?	50	50%	44%	2%	2%	2%
3	Does your institution offer to access e-learning resources which is digital, online, free of charge, free of unnecessary copy right and licensing restriction that can enables any user who has access to the internet to link, read , download, store, print and use it?	45	38%	33%	4%	11%	13%
4	Is there a limited scalability in expanding the functionality an existing e-learning system to the other universities as well?	50	34%	32%	10%	10%	14%
5	Does your universities learning infrastructure facility providing to their students are underutilized.	50	54%	40%	0%	4%	2%

6	Is there a lack of infrastructure facility such as hardware, network, software, platform problems to practical learning support in your university?	50	60%	26%	2%	6%	6%
7	Is there a low performance in accessing an e-learning resource in your institutions?	48	33%	35%	6%	15%	10%
8	Do you think there is limited learning infrastructure resource availability in your institutions?	48	38%	31%	8%	13%	10%
Part 2	**The suggested technology to solve the challenge current system**						
10	Do you think cloud computing helps to solve the problem issued by the current e-learning systems?	46	52%	30%	4%	9%	4%
11	Do you think virtual private cloud can better solve the challenge of e-learning system than other cloud deployment models?	46	48%	26%	9%	11%	7%
12	Do you think using multi-cloud deployment options, all the challenge of an existing e-learning system in your institution can get rid of?	49	45%	37%	6%	10%	2%
13	Do you thing by using cloud federation technology, all						

	the current challenge of e-learning system is going to solved?	49	61%	31%	4%	2%	2%
14	Does your university focuses on the other modern IT system projects, which aim to reduce costs and improve the challenge of current system?	45	29%	27%	18%	13%	13%

Appendix -II: Sample Code

```
package VMallocationInFederatedCloud;
import java.text.DecimalFormat;
import java.util.ArrayList;
import java.util.Calendar;
import java.util.HashMap;
import java.util.LinkedList;
import java.util.List;
import java.util.Map;
import org.cloudbus.cloudsim.Cloudlet;
import org.cloudbus.cloudsim.CloudletSchedulerTimeShared;
import org.cloudbus.cloudsim.Datacenter;
import org.cloudbus.cloudsim.DatacenterBroker;
import org.cloudbus.cloudsim.DatacenterCharacteristics;
import org.cloudbus.cloudsim.Host;
import org.cloudbus.cloudsim.Log;
import org.cloudbus.cloudsim.Pe;
import org.cloudbus.cloudsim.Storage;
import org.cloudbus.cloudsim.UtilizationModel;
import org.cloudbus.cloudsim.UtilizationModelFull;
import org.cloudbus.cloudsim.Vm;
import org.cloudbus.cloudsim.VmSchedulerTimeShared;
import org.cloudbus.cloudsim.core.CloudSim;
import org.cloudbus.cloudsim.provisioners.BwProvisionerSimple;
import org.cloudbus.cloudsim.provisioners.PeProvisionerSimple;
import org.cloudbus.cloudsim.provisioners.RamProvisionerSimple;
public class SimulationofFederatedCloudResourceAllocation {
   private static List<Vm> createVM(int userId, int vms, int idShift) {
      LinkedList<Vm> vmsContainer = new LinkedList<Vm>();
      long size = 10000; //image size (MB)       int ram = 512; //vm memory (MB)
      int mips = 250;       long bw = 1000;       int pesNumber = 1; //number of cpus
      String vmm = "Xen"; //VMM name       Vm[] vm = new Vm[vms];
      for (int i = 0; i < vms; i++) {
         vm[i] = new Vm(idShift + i, userId, mips, pesNumber, ram, bw, size, vmm, new
CloudletSchedulerTimeShared());
```

```
            vmsContainer.add(vm[i]);        }
        return vmsContainer;    }
    private static List<Cloudlet> createCloudlet(int userId, int numberOfCloudlets, int idShift)
{
        LinkedList<Cloudlet> cloudletList = new LinkedList<Cloudlet>();
        long length = 40000;
        long fileSize = 300;
        long outputSize = 300;
        int pesNumber = 1;
        UtilizationModel utilizationModel = new UtilizationModelFull();
        Cloudlet[] cloudlet = new Cloudlet[numberOfCloudlets];
        for (int i = 0; i < numberOfCloudlets; i++) {
            cloudlet[i] = new Cloudlet(idShift + i, length, pesNumber, fileSize, outputSize,
utilizationModel, utilizationModel, utilizationModel);
            cloudlet[i].setUserId(userId);
            cloudletList.add(cloudlet[i]);
        }
        return cloudletList;
    }
    public static void main(String[] args) throws Exception {
        Log.printLine("Starting Simulation ...");
        int num_user = 2;    Calendar calendar = Calendar.getInstance();
        boolean trace_flag = false;  CloudSim.init(num_user, calendar, trace_flag);
Datacenter datacenter0 = createDatacenter("AddisAbabaUniversityDC");
   Datacenter datacenter1= createDatacenter("AdamaScienceandTechonogyUniversityDC");
   Datacenter datacenter2 = createDatacenter("HawasaUniversityDC");
       DatacenterBroker broker = createFederatedBroker("FederatedBroker");
        int brokerId = broker.getId();
        List<Vm> vmList = createVM(brokerId, 10, 0);
        List<Cloudlet> cloudletListToBeSubmitted = createCloudlet(brokerId, 20, 0);
broker.submitVmList(vmList);
        broker.submitCloudletList(cloudletListToBeSubmitted);
        CloudSim.startSimulation();
        List<Cloudlet> receivedCloudletList = broker.getCloudletReceivedList();
```

```
        CloudSim.stopSimulation();
        printCloudletList(receivedCloudletList);
        Log.printLine(SimulationofFederatedCloudResourceAllocation.class.getName()  +  "  is
finished!");
    }
    private static Datacenter createDatacenter(String name) throws Exception {
        List<Host> hostList = new ArrayList<Host>();
        List<Pe> quadCoreMachine = new ArrayList<Pe>();
        int mips = 1000;
        quadCoreMachine.add(new Pe(0, new PeProvisionerSimple(mips)));
        quadCoreMachine.add(new Pe(1, new PeProvisionerSimple(mips)));
        quadCoreMachine.add(new Pe(2, new PeProvisionerSimple(mips)));
        quadCoreMachine.add(new Pe(3, new PeProvisionerSimple(mips)));
        List<Pe> dualCoreMachine = new ArrayList<Pe>();
        dualCoreMachine.add(new Pe(0, new PeProvisionerSimple(mips)));
        dualCoreMachine.add(new Pe(1, new PeProvisionerSimple(mips)));
        int hostId = 0;       int ram = 8000;   long storage = 1000000; //host storage
        int bw = 10000;
hostList.add( new Host( hostId,new RamProvisionerSimple(ram),
newBwProvisionerSimple(bw),storage,quadCoreMachine,
newVmSchedulerTimeShared(quadCoreMachine))); // This is our first machine
hostId++;
hostList.add( new Host( hostId, new RamProvisionerSimple(ram),
new BwProvisionerSimple(bw),storage,dualCoreMachine,
new VmSchedulerTimeShared(dualCoreMachine))); // Second machine
hostId++;
hostList.add( new Host( hostId,  new RamProvisionerSimple(ram),
new BwProvisionerSimple(bw), storage,  dualCoreMachine,
new VmSchedulerTimeShared(dualCoreMachine))); // Third machine
        String arch = "x86"; // system architecture
        String os = "Linux"; // operating system
        String vmm = "Xen";
        double time_zone = 10.0; // time zone this resource located
        double cost = 3.0; // the cost of using processing in this resource
```

```
        double costPerMem = 0.05;       // the cost of using memory in this resource
        double costPerStorage = 0.1;    // the cost of using storage in this resource
        double costPerBw = 0.1;// the cost of using bw in this resource
        LinkedList<Storage> storageList = new LinkedList<Storage>();
        DatacenterCharacteristics characteristics = new DatacenterCharacteristics(arch, os,
vmm, hostList, time_zone, cost, costPerMem, costPerStorage, costPerBw);
        FederatedVmAllocationPolicy vm_policy =
new FederatedVmAllocationPolicy(hostList);
        return new Datacenter(name, characteristics, vm_policy, storageList, 0);
    }
    private static DatacenterBroker createFederatedBroker(String name) throws Exception {
        return new FederatedDatacenterBroker(name);
    }
    private static void printCloudletList(List<Cloudlet> list) {
        int size = list.size();
        Cloudlet cloudlet;
        String indent = " ";
        Log.printLine();
        Log.printLine("========== OUTPUT ==========");
        Log.printLine("Cloudlet ID" + indent + "STATUS" + indent
                + "Data center ID" + indent + "VM ID" + indent + indent + "Time" + indent +
"Start Time" + indent + "Finish Time");
        DecimalFormat dft = new DecimalFormat("###.##");
        for (int i = 0; i < size; i++) {
            cloudlet = list.get(i);
            Log.print(indent + cloudlet.getCloudletId() + indent + indent);
            if (cloudlet.getCloudletStatus() == Cloudlet.SUCCESS) {
                Log.print("SUCCESS");
                Log.printLine(indent + indent + cloudlet.getResourceId()
                        + indent + indent + cloudlet.getVmId()
                        + indent + indent + dft.format(cloudlet.getActualCPUTime())
                        + indent + indent + dft.format(cloudlet.getExecStartTime())
                        + indent + indent + dft.format(cloudlet.getFinishTime()));
            }}  }  }
```